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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

AUGUST 1925

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

THE total possible stretch in a Stabilator strap is something less than one inch.

And this stretch causes the Stabilator to hold more powerfully.

Right there, in this fact that stretch causes the hold to become more powerful, you have positive proof that a Stabilator is precisely the opposite of any other device on the market. Just mull that over and see what it means.

THE

JOURNAL
OF THE SOCIETY OF
AUTOMOTIVE ENGINEERS

Published by the SOCIETY OF AUTOMOTIVE ENGINEERS, INC., 29 *W. 39th St., New York*

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H. L. HORNING, *President* COKER F. CLARKSON, *Secretary* C. B. WHITTELSEY, *Treasurer*

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The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

WYMAN-GORDON

CRANKSHAFT MAKERS TO THE INDUSTRY

WORCESTER, MASS. HARVEY, ILL.
CLEVELAND DETROIT

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XVII August, 1925 No. 2

Chronicle and Comment

After Motorboats Comes Production

"BOUTON, Frauenthal, Herrmann, Roberts, Teachout, Younger"; thus reads the roster of members who are making rapid progress in arranging the "Production Meeting for Production Men" to be held in Cleveland, Sept. 14, 15 and 16. Interesting material pertaining to the meeting will be found on p. 147 of this issue, and further details will later be published both in THE JOURNAL and in the *Meetings Bulletin*. Watch for them!

Deliveries Delayed by Non-Standard Parts

WHEN a designer specifies that an S.A.E. Standard bolt for a certain part shall have a head height 1/64 in. greater than standard, he probably does not appreciate he has ruled that the part shall be made as a special order at a cost greater than necessary and that deliveries will be delayed, no matter how urgent the telegrams are that inevitably accompany the rush season.

That specifying such immaterial variations from the S.A.E. Standards is common practice is indicated by E. H. Ehrman's check of a screw manufacturer's product that nominally would be considered S.A.E. Standard. Of this product, 72 per cent was made on special order, owing to just such immaterial differences as cited.

Many executives unquestionably watch this condition closely, but Mr. Ehrman's figures, which are taken from the progress report of the Screw-Threads Division on p. 151 of this issue, indicate that the majority of engineers and executives do not pay adequate attention to such details.

Purchasing Power

AN investigation of income and buying power of the American people, as it varies in different States and at different stages of the business cycle, has been undertaken by the National Bureau of Economic Research, of New York City. It is felt that this work will have a beneficial effect in helping to eliminate some of the waste caused by misdirected selling effort, to make taxation issues clearer and to aid all who are desirous of understanding National economic conditions.

The determination of the "actual income" sought to be ascertained by the inquiry requires a study of the facts relating to the incomes of over 40,000,000 people. Tax data include returns made by less than 8,000,000 people and, moreover, owing to exemptions, do not indicate accurately the status of even a fraction of income receivers. The report is intended to be chiefly a statistical presentation of the more salient factors pertaining to the income of the people of the United States and the sources of the geographical distribution of the income.

The Bureau of Standards

THE value of basic research, aimed at the acquisition of knowledge without immediate utilitarian objectives, was emphasized in a report made recently by the Visiting Committee of the Bureau of Standards. This Committee, which consisted of W. D. Bancroft, Gano Dunn, W. F. Durand and Ambrose Swasey, expressed the belief that such work should be undertaken to a greater extent than heretofore. The Committee points out that the history of civilization presents many illustrations of the utilization for the good of humanity of the results of scientific work undertaken without reference to its direct value and often remaining unused long after its first announcement.

The report also calls attention to the value of industrial research. Both types of research are essential to the welfare and industrial prosperity of the Nation. The economies resulting from them are often great, and are necessary in maintaining in this Country the present high wage-rates and high standards of living in times of worldwide intense industrial competition.

Motorboat Meeting This Month

"WHEN I am looking for real pleasure, rest and relaxation, far away from the crowds, I jump aboard the little old boat and cruise along the coast, leaving my troubles and worries behind." Whoever unburdened himself of this remark expressed very aptly the attitude of a host of his fellowmen.

If one can judge from many clear indications, the number of those who are adopting the motorboat as a medium for pleasure and business is rapidly increasing and the craft are rapidly and surely coming into their own. The rising popularity and the greater demand has necessarily served to emphasize, in the industry, many problems of design and production and has brought about new developments and improvements.

In line with the Society's long established policy to promote and foster progress in this important branch of engineering, the plans for the 1925 Motorboat Meeting have been laid with a view to bringing before our members and others who are interested the latest thought in the development of the field. Members will find it worthwhile to read the outline of plans for the meeting, scheduled for Aug. 27 at New York City, as they are presented on p. 147 of this issue. Additional details will appear in a forthcoming *Meetings Bulletin*.

Have You a Paper To Present?

ATTENTION has often been directed, through these columns, to the desire that members make known to the Meetings Committee their willingness to present papers at the Society's meetings. President Horning has stated that a member can perform no better service, both for himself and for the Society, than the preparation and presentation of a creditable paper pertaining to a topic that the writer is well qualified to discuss. It is again urged that the members offer their assistance to the Committee and that they do so well in advance of the meeting in which they wish to participate.

Intercity Airplane Tour

FOLLOWING the discussion that has been had for some time, it was decided at a meeting held in Detroit last month by the Directors of the Detroit Aviation Society, to schedule definitely an Intercity Airplane Tour of 6 days' duration, commencing Sept. 28. The time of the event was placed later in the month than was originally proposed, to provide more time for perfecting plans and to avoid dates too close to Pulitzer Race Week.

Edsel Ford has offered the trophy to be competed for. The participants will be exclusively civilian. It is understood that many of the airplane manufacturers will make entries.

The tour will start and end at Ford Airport, Dearborn, Mich. The length of the route is about 1900 miles, the longest hop being approximately 400 miles and the shortest about 200 miles. The over-night stopping-points that have been tentatively scheduled are Chicago, Omaha, Kansas City, St. Louis and Columbus.

The Detroit Aviation Society is the principal sponsor of the tour, which has been sanctioned by the National Aeronautic Association.

An exposition of aeronautical exhibits will be held at Ford Airport during the week of the Tour. It is expected that there will be many features of interest to the aeronautic industry and the public, in addition to the Tour itself, the purpose of which is to demonstrate further the ability and reliability of aircraft as well as to make many more people familiar with the many ways in which it can be made useful and profitable.

Traffic-Signal Color-Code Report

THE Sectional Committee, organized under the procedure of the American Engineering Standards Committee, and sponsored by the American Association of State Highway Officials, the National Safety Council and the Bureau of Standards, has submitted the revised draft of its Code of Colors and Forms for Traffic Signals for Highways and Vehicles to the members of the Committee for approval by letter-ballot. It will thereafter be submitted to the sponsors for their approval and then to the American Engineering Standards Committee for final approval as to Committee organization and procedure. The Code is being submitted for adoption as American Standard. The purpose and scope are:

> The purpose of this code is to provide a standard of colors and methods, as applied to highway traffic and vehicles, which will promote uniform usage and thus decrease the likelihood of accidents and conserve human life and limb.
>
> This Code is intended to cover the use of luminous and non-luminous signs and signals in connection with highway traffic, including moving and flashing signals, and the use of lights, semaphores and other signaling devices on vehicles.

It specifies that headlights shall be white, amber, yellow or any intermediate hue, and that no red or green lights shall be displayed on any vehicle that will be visible from a point directly in front of it. Red is recommended for tail-lights because of the present universal use of this color for this purpose but, in case of a change in color in any jurisdiction, yellow is recommended. Yellow is approved for signal lights on automobiles, red or green being definitely ruled out. Provision is made for non-luminous mechanical signals of a semaphore type to project from the left side of the vehicle and limited to the horizontal position when projected. Yellow marker-lights visible from the front and the rear of the vehicle are specified, to be placed in the upper left-hand corner to indicate the dimensional limits of vehicle bodies or loads.

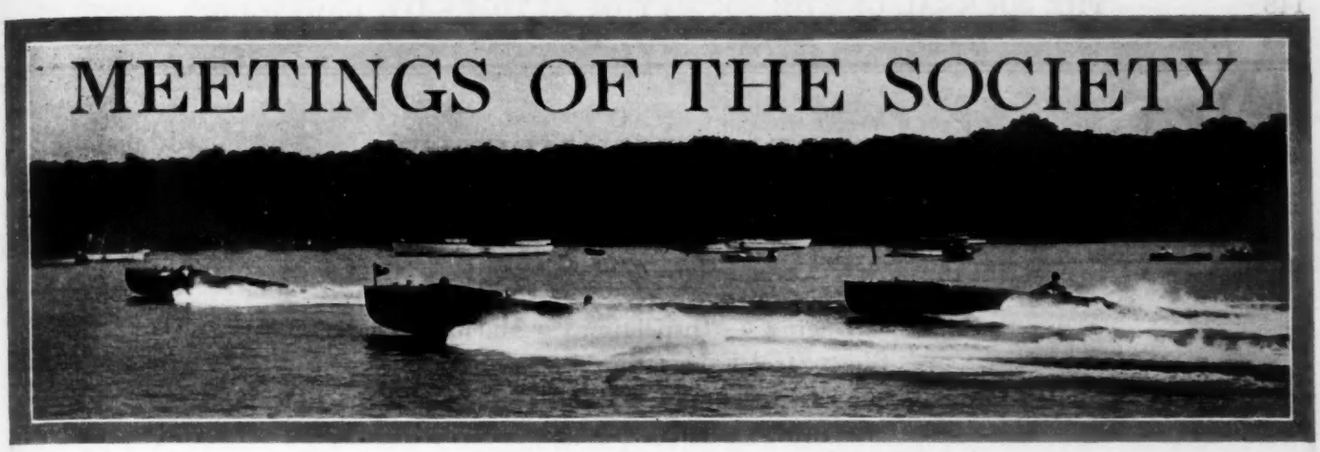
The colors recommended in the Code have the following significance:

(1) Red shall be used as an indication to stop and for other purposes where required by law
(2) Yellow shall be used as an indication to exercise caution
(3) Green shall be used as an indication to proceed

The Code contains definite specifications for the operation, position and colors for semaphore, worded and illuminated signals for directing traffic at railroad and other crossings, as well as signs and symbols for instructing or cautioning vehicles while in motion. Other rules in the Code relate to the location of signs, precautionary signs for pedestrians, operating time for automatic signal devices, and flashing-light and wigwag types of signal. The definition of colors specified in the Code, the dominant wave-lengths, percentages of purity, integral transmission of glass for luminous signals and the quantitative definition of colors for non-luminous signals are specified, based on the methods and data described in the colorimetry report of the Optical Society of America. A chart of 13 recommended signs for road-turns, intersections and under-pass and railroad crossings is also appended.

The Society is represented on the Sectional Committee by W. A. McKay, who has been an active member of the Lighting Division of the Standards Committee for several years.

MEETINGS OF THE SOCIETY



SUCCESSFUL BOAT MEETING ASSURED

Event on First Day of Gold Cup Regatta Will Draw Prominent Engineers

Can you, as a motorboat engineer, imagine a more attractive and worthwhile event than a friendly tilt by qualified experts over the many problems that are now confronting the motorboat fraternity?

Do not misunderstand this inquiry. The Society's 1925 Motorboat Meeting, to be held in New York City the evening of Aug. 27 at the Hotel Commodore, is not being planned as a battle royal but rather as a spirited discussion of important engineering phases of the industry. Facts and figures, surprises and disclosures will begin to find expression promptly at 8 p. m.

George F. Crouch to Speak

George F. Crouch, vice-president and general manager of the H. E. Dodge Boat Works, Inc., of Detroit has definitely promised to be on hand and speak concerning stock boat production. He will also raise many important points of interest in his discussion of forward steps in the design and construction of motorboats, of both the racing and the cruising types. Mr. Crouch's presentation no doubt will go far toward answering the question of how the engineering branches can be developed to assure the rapid and successful growth of the motorboat industry commensurate with the ever-increasing popularity of and demand for its products.

Commodore Gar Wood, Irwin Chase, Scott Mathews, Chris Smith and other well-known engineers of the highest caliber are expected to be present and offer their ideas also. C. A. Carlson, president and general manager of the New Jersey Motors Co., Inc., and second vice-president of the Society, will preside at the meeting.

Meeting Open to Non-Members

All engineers interested in motorboats and motorboat engineering, whether they are members of the Society or not, are invited to attend this meeting.

Remember the time, 8 p. m., Aug. 27, the evening of the first day of the Gold Cup Regatta of the American Power Boat Association. And remember the place, the Hotel Commodore, New York City. Additional details will appear in the forthcoming issue of the *Meetings Bulletin*.

CLEVELAND IN SEPTEMBER

Production Meeting Committee Preparing To Stage an Event of Tremendous Appeal

With its slogan "A Production Meeting for Production Men," the committee in charge of the 1925 Production Meeting is exerting every effort toward staging a meeting that will make a tremendous appeal to all who are interested in this most important branch of industrial activity. The sessions will extend over the 3-day period, Sept. 14, 15 and 16, and will cover the subjects of gears, machine tools, sheet-steel fabrication, gaging and inspection, heat-treating and the training of foremen and mechanics. The technical

GEORGE F. CROUCH will speak at

THE MOTORBOAT MEETING!

Other Prominent Engineers Will Discuss Important Problems of the Motorboat Industry

All are invited to attend this open meeting

Hotel Commodore 8 p.m. (Daylight Saving Time) Aug. 27 New York City

A PRODUCTION MEETING FOR PRODUCTION MEN!

Gears — Gaging — Inspection — Machine Tools
Sheet-Steel Fabrication — Training

Hotel Winton Sept. 14, 15 and 16 Cleveland

Gigantic Steel Exposition of the
American Society for Steel Treating

A FEATURE OPEN TO S.A.E. MEMBERS

sessions will be held in the Hotel Winton, which will serve as Society headquarters.

Excellent Speakers Promised

James B. Dillard, general superintendent of the Cleveland Twist Drill Co., will present a paper on Bringing Machine Tools Up to the Level of Cutting Tools. It is expected that L. L. Roberts, manager of production, Packard Motor Car Co., will discuss What Is Needed by the Industry in the Way of Machine Tools.

At the session on Gaging and Inspection, the well-known C. E. Johannson, who is connected now with the Ford Motor Co., will offer a paper that is certain to be of great value. Others who are also prominent in the gaging and inspection field will participate in this session.

Louis Ruthenberg, general manager of the Yellow Sleeve Valve Engine Works, has consented to present a paper on the Training of Foremen. Mrs. Lillian M. Gilbreth of the Frank Gilbreth Co., Inc., is to speak on Training Employes in Production Work. Mrs. Gilbreth is a practical authority of international renown who has won distinction in the study and teaching of "the one best way."

P. L. Tenney, engineer of the Muncie Products Division of the General Motors Corporation, has a wealth of extremely interesting material that he will present at the Gear Session. Arrangements are practically completed with a second speaker for this session. He will discuss the production of spiral bevel gears and extensive development work on rear-axle housings.

Other speakers cannot yet be announced but the com-

NATIONAL MEETINGS CALENDAR

MOTORBOAT MEETING—New York City—Aug. 27

PRODUCTION MEETING AND EXPOSITION—Cleveland—Sept. 14, 15 and 16

AERONAUTIC MEETING—New York City—October

AUTOMOTIVE TRANSPORTATION MEETING—Philadelphia—Nov. 12 and 13

SERVICE ENGINEERING MEETING—November

ANNUAL DINNER—New York City—Jan. 14, 1926

ANNUAL MEETING—Detroit—January, 1926

mittee gives assurance that they will be of the highest order and that they will present material of real worth to those who are associated with production activity.

National Steel Exposition a Great Attraction

The National Steel Exposition, the largest ever held in the world, will be staged at the Public Auditorium by the American Society for Steel Treating. Members of the Society of Automotive Engineers have been invited to attend.

Steel will be seen passing from the raw stage through the machine tools, the heat-treating processes and final inspection to the finished product. In the machine-tool section nearly 100 exhibits will be in actual operation under factory and production conditions. The total number of exhibits will be about 170.

Delightful Entertainment Features

Through the generosity of the American Society for Steel Treating, with which the Society is cooperating, several attractive entertainment events will be open to our members.

On Tuesday evening, Sept. 15, a smoker and frolic that will include high-class boxing bouts and a battle royal will be given. On Wednesday evening the entertainment provided will be in the form of a dance in the ballroom of the Cleveland Hotel. The Sleepy Hollow Country Club and the Cedarhurst Country Club have offered golfing privileges to our members. Sightseeing tours, theater parties and other forms of entertainment will be arranged especially for the ladies.

Additional details concerning this best of all Production Meetings will appear in the September issue of THE JOURNAL and in the *Meetings Bulletins*.

NATIONAL MEETINGS APPROACHING

Aeronautic, Transportation, and Service Meetings Forming in the Offing

Some uncertainty still exists about the exact date of the Society's National Aeronautic Meeting, although it probably will be held in New York City during the Pulitzer Prize Race Meet. Present indications are that this race meet will be held Oct. 8, 9 and 10 at Mitchel Field, Long Island.

A. W. S. Herrington and his Transportation Meeting Committee are at work on the program for the Annual Transportation Meeting that has been scheduled for Philadelphia, Nov. 12 and 13.

The Service Engineering Meeting is also planned for November and doubtless will be held again in cooperation with the National Automobile Chamber of Commerce, as was the one in Detroit last May.

Later additional information pertaining to the foregoing events will be announced in due course.

THE STATUS OF THE FARMER

EVERY reason exists for believing that the farmer's income this year will be larger than last. It was the revival of his purchasing power that gave industry its upturn in the fall of 1924. The continuance of agricultural prosperity will serve to maintain the situation this autumn. The immediate outlook for the future of agriculture is favorable.

Today farms are fewer in number and fewer persons are engaged in farming than was the case 15 years ago. Yet our urban population has continued to grow rapidly since the beginning of this century. In 1900 some 45,000,000 people were living in cities and towns; today this has increased to over 80,000,000. By 1930 the number of persons in these villages and urban communities to be fed by the farmers of this Nation will be 90,000,000. It is clear, then, that the demand for agricultural products is on the increase now, as it was in those 17 years that succeeded the revival of prices and of business in 1896. It is clear, too, that unless the supply of agricultural products increases in an unusual manner, their prices will hold the advance that they have made. On the demand side the forces that will maintain agricultural prices constant are clear as the noonday sun.

High prices will stimulate production as they have during the last three decades. Only about 10 per cent more people are engaged in agriculture today than in 1900, yet they bring forth 40 per cent more product, measured in actual physical units, such as bushels, tons, gallons and dozens. Anyone who is acquainted with the field of agriculture knows that the people now engaged in farming can increase their output to meet the growth of population for several decades to come if the price inducement is sufficient. Higher prices will increase the use of fertilizer, machinery and better methods. Such an increase comes gradually, so that the danger of a supply greatly in excess of demand at profitable prices is slight. But every prospect indicates that prices will be profitable, and that the farmer will find in them a sufficient inducement to feed the people of this Nation abundantly, as he has fed them in years gone by, and that they will give him a reward that will enable him to maintain a constantly increasing standard of living, as he has in the past.—From an address by David Friday before National Association of Credit Men.

COMMERCIAL AVIATION IN THE UNITED STATES

THE American Railway Express Co. every evening sends from New York City several trains bound for Chicago. Nearly 24 hr. is required to make the journey; the best delivery we can make is on the second morning. Each night we send out of New York City 14 exclusive express trains, comprising from 400 to 500 solid express carloads. The value of these shipments will average around $12,000,000 per day. Would it be strange if, in this great volume, there were enough traffic in small valuable packages that would be glad to avail itself of aviation service? I believe that accelerated transportation of this kind would develop a traffic of its own. It would not be long before banks and merchants and manufacturers would be figuring on how they could use this service to their advantage. And ere a great while should pass, we would feel that it would be impossible to do without the commercial airplane.

It is not to be expected that the venture will revolutionize all methods of transportation. New transportation facilities, instead of abolishing facilities of proved worth already in operation, have resulted in creating new business that is exclusively their own.—President Cowie, American Railway Express Co.

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S. A. E. Standards Committee and other standards activities are reviewed herein

LAMP GLASSES NEED SIMPLIFICATION

60 Per Cent of Tail-Lamp Glasses in Agreement with Standard 3-In. Diameter

In 1917 the Society adopted as S.A.E. Standard a 3-in. diameter for tail-lamp glasses. A recent survey of the passenger-car and motor-truck builders' practice shows that, out of 72 companies submitting data, 27 are using the 3-in. diameter; 19 are using diameters other than 3 in., ranging from 2 to 3½ in.; and 26 are using tail-lamp glasses of special designs. Of the companies using the type of tail-lamp glass covered by the S.A.E. Standard, approximately 60 per cent follow the standard diameter.

The principal need for a standard tail-lamp glass from the standpoint of the car builder is to obtain interchangeability between the glass and the tail-lamp. The glass manufacturers, however, are interested in reduction of the number of styles of 3-in. diameter glass that are required by the car producers. Comments of the manufacturers in this connection follow:

> You would be astonished to know how many different types we make and how useless it all is. While you list only the 3-in. tail-lamp glass, the fact remains that we make six different 3-in. tail-lamp glasses, to say nothing of the 38 other odd sizes.
>
> You may wonder why six different 3-in. lenses are made. One lamp house insists on a certain number of corrugated steps, another either a greater or a lesser number of steps, while another wants concentric rings. So it goes, until we not only have to make an abnormal number of different molds, but must stock each one of these items. This has always seemed to us to be absurd.
>
> In addition to making all of these various types of inside corrugated tail-lamp glass, we are required to make a vast variety of plain concave convex glasses, in which considerable duplication exists. Our stock list shows 76 sizes.

> At present most manufacturers are compelled to maintain mold equipment and stocks of from 10 to 20 shapes and designs of the 3-in. lens. In our opinion one lens could easily replace all of those without in any way affecting service results.
>
> Recently a tendency on the part of some to depart from the usual red color for the regular tail-lamp has been noticed: In our opinion this is needless and serves only to complicate matters. We recommend that the regular red, defined by the specifications of the American Railway Association, be adhered to for this purpose, except that definite values for transmission should not be insisted upon.
>
> We recommend also that in all combination tail and stop-lamps, the 3-in. inside corrugated lens be maintained as standard for the tail-light. Moreover, that in these combination lamps the use of glass segments be eleminated entirely. It is feasible to use a cylindrical cup in these combination lamps in much the same manner as it is used in the regular tail-lamp, the only difference being one of size.

As it is recognized that the problem facing the glass manufacturers is largely a matter of simplification, it has been suggested that the Division of Simplified Practice of the Department of Commerce undertake to bring about further simplification through the cooperation of the glass manufacturers and users.

NO. 00 FLYWHEEL HOUSING SUGGESTED

Dimensions have been proposed by the Engine Division for a flywheel housing larger than the present No. 0 size, for industrial applications. The dimensions have been approved by the companies building this large type of engine and final action will be taken at the next meeting of the Division.

The dimensions proposed are given herewith.

PROPOSED DIMENSIONS FOR NO. 00 FLYWHEEL HOUSING

Inside Diameter, in.	31.000 to 31.010
Outside Diameter, in.	34¾
Bolt-Circle Diameter, in.	33½
Bolt Holes	16
Bolt-Hole Diameter, in.	17/32

CORONA CABLE-TESTS INCONSISTENT

Electrical Equipment Subdivision Not in a Position To Recommend Standard Tests

Over a year ago a special subcommittee of the Insulated Cable Subdivision of the Electrical Equipment Division was appointed under the chairmanship of D. M. Pierson to develop a satisfactory corona test for high-tension insulated cable. At the time the committee was appointed it was thought that a standard test using a transformer as a current source would give consistent results such as had not been obtained by the use of a magneto. The tests made to date by the Subdivision, however, show that a transformer does not give consistent results.

The Underwriters' Laboratories considers that the corona test that it is now using is satisfactory. The test requirements, taken from the Underwriters' Laboratories Standard for Insulated Cable, read as follows:

> Six samples of each size of cable shall withstand, without failure, a "corona" test for a period of 25 continuous min.
>
> For this test a four-point magneto, running at a speed of approximately 1800 r.p.m., is used. The sample cable to be tested is closely wound around an arbor 1 in. in diameter and 15 in. long, for 10 turns. The arbor is supported at each end by copper brackets. One end of the test specimen is connected directly to the magneto; the other end to a 6-mm. (0.236-in.) spark-gap. Two standard steel needles, mounted on a bakelite base, are spaced so as to allow an air-gap of 6 mm. (0.236 in.). The gap unit is insulated from the base of the apparatus by porcelain insulators. One end of the arbor is grounded directly to the magneto.

To determine to what extent the industry is familiar with the corona test, a general letter was sent to the larger passenger-car builders asking for information as to experience with tests of this type and whether such tests should be included in the S.A.E. Cable Standard.

The letter was sent to 31 car builders, replies from 15 being received. Of those replying, 12 were not familiar with the test. It is assumed that replies were not received from the other 16 because they also were unfamiliar with the test. The comments received from the three companies familiar

with the corona test are of considerable interest and are given herewith.

Comments of Car Manufacturers

We have had some experience with the corona test but the results are lacking in uniformity and seem to to afford no basis upon which a reliable test specification could be built.

We believe that such a test would be of considerable value if the phenomena can be accurately analyzed and controlled for test purposes. At the present time our experience has shown that what little is generally known may be applied to tests in such a way as to be worse than useless.

All of our tests have been made with current supplied by battery ignition. Up to the present time we have not found a test that will give results consistent enough to warrant using it in connection with our cable specifications. We expect to do some additional work along this line.

During the last 2 years of testing and experimenting with this method, we find, as do others, that a variable factor is present which makes the results inconsistent.

We have found, however, that the corona will detect inferior cable; consequently, it should be considered as having some merit. We have accumulated considerable data on performance of the corona test under normal and artificial atmospheric conditions and would be pleased to compare notes with others having experience with corona testing.

We feel that someone will discover the cause of the variable; once this is positively known, the corona method will then be the cheapest method of testing the insulating qualities of high-tension cable.

ENGINE TRUNNIONS PROPOSED

At the last meeting of the Engine Division the recommendation given in the following table was proposed for standard engine front-trunnion dimensions.

PROPOSED ENGINE FRONT-TRUNNION DIMENSIONS

Type	Diameter, In.	Minimum Length, In.
Starting Crank }	2½	1¼
Bracket }	3	1¼
Gear Cover	3¾	1½
	5	1½

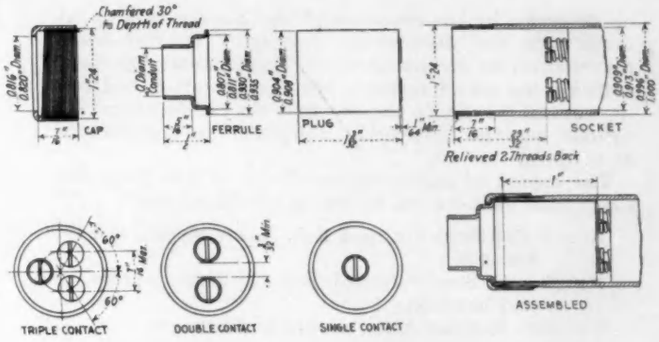
The dimensions are intended for future practice only, present practice being so divergent that no satisfactory standard can be recommended for current engine design.

In order that the Engine Division may base its final action on this proposal on the consensus of opinion of the companies building engines, the proposal has been referred to passenger-car companies building their own engines and to engine builders, for comment and criticism.

SCREW-TYPE CONNECTORS RECOMMENDED

Bayonet-Type Not Suitable Because of Severe Vibration in Motorcoach Service

Since the present S.A.E. Standards for Bases, Sockets and Connectors were first criticised in 1922 as being unsatisfactory for motor-truck service, the Lighting Division Subcommittee on Bases, Sockets and Connectors has made a careful study of the needs of the automobile industry for lighting equipment. The information obtained during this time has shown conclusively that the present standards are satisfactory for passenger-car service, but that a stronger connector should be used for motor-truck and motorcoach service owing to the severe vibration encountered. C. E. Godley, chairman of the Subcommittee, developed several types of connector which were considered. At the meeting held on May 14 a recommendation covering a screw type of connector was proposed. The Subcommittee approved this type but recommended that the outside diameter of the socket be increased to 1 in. in order that it might easily accommodate three contact plungers. This is desirable owing to the development of the double-filament lamp using an insulated return. It is also considered possible that four-contact connectors will be used. The dimensions approved permit the use of the wires necessary for this construction.



Type of Screw Connector Recommended for Motorcoaches
The Severer Vibration Encountered in Motor-Truck and Motorcoach Operation Renders the Bayonet-Type Connector, Which Is Suitable for Passenger-Car Use, Unfit for These Classes of Service. Connectors of the Proposed Type Have Been Tested in Service with Satisfactory Results

The type of connector proposed, which is shown in the accompanying illustration, has been produced in substantially the dimensions recommended and has stood up satisfactorily in service. The Division tentatively approved the dimensions proposed at the May 14 meeting and, if it shall be found that the recommendation meets the general approval of the motor-truck and motorcoach industries, it will be proposed for adoption as S.A.E. Recommended Practice at the January Meeting of the Standards Committee.

BOLT STANDARD TO BE REVISED

72 Per Cent of One Manufacturer's Production Not in Accordance with S.A.E. Standard

At the meeting of the Standards Committee held on June 18 at White Sulphur Springs, E. H. Ehrman, chairman of the Screw-Threads Division, submitted a progress report covering the action proposed by Subcommittee No. 2 of the Sectional Committee on Bolts, Nuts and Rivet Proportions which will require revisions of the present S.A.E. Standard for Screws, Bolts and Nuts, p. C2 of the S.A.E. Handbook. In discussing this report, Mr. Ehrman brought out the fact that 72 per cent of the product of one manufacturer, which would nominally be considered as S.A.E. Standard, was, owing to minor variations, classed as special, resulting in special runs and delayed shipments.

The Sectional Committee referred to was organized by the American Society of Mechanical Engineers and the Society under the rules of procedure of the American Engineering Standards Committee.

Mr. Ehrman's progress report, together with the discussion thereon, follows:

Progress Report of the Screw-Threads Division

It has been arranged that a progress report on the tentative specifications for the wrench-head dimensions of screws, bolts, and nuts be made at this time by the members of the Screw-Threads Division that represent the Society on the Sectional Committee responsible for the revision and correlation of standards with respect to bolts, nuts and rivets. Under the present procedure, through American Sectional Committees sponsored by the technical societies, the formulation or revision of standards is not under the direct and sole control of the Society, and, inasmuch as such standards when approved are revised with difficulty, great care must

be exercised by the members of the Society to keep in touch with the work or to thoroughly instruct their representatives on the Sectional Committees regarding not only the major matters, but also the oft-considered immaterial details, to the end that the complete specifications may be thoroughly acceptable to the Society as a whole.

The report of Subcommittee No. 2 of the Sectional Committee includes the following specifications:

Rough and Semi-Finished Bolt Heads, square and hexagon
Rough and Semi-Finished Regular Nuts, square and hexagon
Finished Regular Nuts, square and hexagon
Finished and Semi-Finished Thin Nuts, hexagon
Cap-Screw Heads, hexagon
Light Nuts, hexagon
Finished and Semi-Finished Bolt Heads, square and hexagon
Machine-Screw Nuts
Wrench Openings

The proportions of heads and nuts are as follows, D being the bolt diameter:

Head Height, Rough Bolts, = $\frac{2}{3}$ D
Head Height, Finished and Semi-Finished Bolts and Cap Screws = $\frac{3}{4}$ D
Nut Thickness, Regular and Light = $\frac{7}{8}$ D
Nut Thickness, Thin = $\frac{1}{2}$ D + Range Constant
Top of Head and of Nut, Flat and Chamfered
Bearing Surface[1] of Head or Nut, Finished or Semi-Finished, = Washer Face
Thickness of head or nut is measured from bearing face to flat of top
Hole of nut countersunk on bearing side

Specifications having to do with the body, thread and point of bolts and screws will be formulated by another subcommittee of the Sectional Committee, and will include the following:

Shape of point of bolt or screw, whether oval, or flat and chamfered
Measurement of length of body of bolt or screw, whether inclusive or exclusive of chamfer or oval of point
Length of threaded portion of bolt, intended for assembly with nut
Length of threaded portion of screw, intended for assembly in tapped holes other than nuts
Tolerances in body diameter

The table of the diameters of heads and nuts, taken from the tentative report, is given in the accompanying table.

	Rough and Semi-Finished	Finished	Nuts			
Bolt Size	Bolt-Heads	Bolt-Heads	Regular	Rough-Finished Semi-Finished	Cap-Screw Heads	Light Nuts
1/4	3/8	7/16		7/16	7/16	7/16
5/16	1/2	9/16		9/16	1/2	1/2
3/8	9/16	5/8		5/8	9/16	9/16
7/16	5/8	3/4		3/4	5/8	5/8
1/2	3/4	13/16		13/16	3/4	3/4
9/16	7/8	7/8		7/8	13/16	
5/8			15/16		7/8	
3/4			1-1/8		1	
7/8			1-5/16		1-1/8	
1			1-1/2		1-5/16	
1-1/8			1-11/16		1-1/2	
1-1/4			1-7/8		1-11/16	
1-1/2			2-1/4			

Fine screw-threads are recommended for use in Light Nuts, but the report indicates no choice of thread pitch for other series of bolts or nuts in the inch sizes. It is expected that the Society will compile from these data a specification to supersede the present S.A.E. Standard for bolts, screws and plain nuts.

In the revision, no change has been made in the diameters of the head or nut in the present S.A.E. Standard from the 1/4 to and including the 9/16-in. sizes. Above the 9/16-in. size, there is a choice of the Finished-Bolt Series, in which the head diameters are slightly greater than those of the present S.A.E. Standard; or of the Cap-Screw Series, above the 1/2-in. size, in which the head diameters are somewhat less than in the present S.A.E. Standard.

The cap-screw manufacturers, through a committee that met in Chicago on May 19, have made a recommendation to the Society, urging the selection of the Cap-Screw Series, in preference to the Finished-Bolt Series, for sizes larger than 1/2 in., their communication reading, in part, as follows:

> In adopting the proposal of Subcommittee No. 2 on Hexagon-Head Cap-Screws, the height of all standard cap-screws will be commercially made in what has been commonly considered the Coarse-Thread Series with a height of head three-quarters of the bolt diameter rather than with a head height equal to the bolt diameter as heretofore. This change eliminates the two existing standards in cap-screw head heights and further action of the Committee in accepting the flat top and chamfered head with a faced bottom underneath will make all cap-screws up to and including 1/2 in., whether threaded with a coarse or a fine thread, identical with the S.A.E. Screw and Bolt Standards, adopted by the Society in June, 1911, and revised in August, 1916.
>
> If the S.A.E. Screw and Bolt Standard is revised for sizes 9/16 in. and larger in accord with Table No. 5 of the Tentative Standard of Subcommittee No. 2 on head diameters, uniformity will exist in all cap-screws regardless of whether coarse or fine threads are specified.
>
> Cap-screw manufacturers can do nothing toward standardization of cap-screws beyond their present action, and it would be unfortunate, in manufacturing as well as for the users of cap-screws, if the S.A.E. Standard should remain as at present.
>
> Our Cap and Set-Screw Standards Committee therefore recommends to the Society of Automotive Engineers that it revise its present standard at as early a date as possible consistent with the final approval of what is at the present date the Tentative Report of Subcommittee No. 2 on Wrench-Head Bolts and Nuts.
>
> (Signed) E. M. WHITING,
> Secretary, Cap-Screw
> Manufacturers Committee.

Inasmuch as several members of the Screw-Threads Division are identified with the cap-screw manufacturers, and other members are identified with the bolt manufacturers, the matter of recommendation with respect to the selection of the larger end of the S.A.E. Series, by the Division, would be a rather delicate matter, and, inasmuch as the determining factor in the selection will be the engineering and economic requirements, it has been thought best in this instance to present both sides to the Society but to make no recommendation. It is to be noted that the cap-screw in the larger sizes, on account of the smaller head, will be a trifle lower in cost than the finished bolt; likewise a trifle cheaper than the present S.A.E. bolt. On the other hand, the finished bolt provides a head of the same diameter as that of the nut used with the bolt, which is not the case with the cap-screw. The diameter of the bolt head is such, however, that the cost of the finished bolt will be a trifle greater than that of the present S.A.E. bolt, as well as that of the cap-screw.

THE DISCUSSION

CHAIRMAN C. M. MANLY:—Why is a cap-screw not a bolt?

E. H. EHRMAN:—The cap-screw in the past has been a product of a more finished nature than the common bolt

[1] Flat and chamfered face is optional for the Thin Nut.

and derives its name, without doubt, from its principal application, that of holding a cap in place. The word "bolt," unqualified, ordinarily, although not necessarily, includes two components, the bolt proper and the nut, the latter forming the retaining part of the unit. A stud bolt implies a bolt rigidly set in place, the head being replaced by a threaded end. A tap bolt implies the application of a bolt in a tapped hole, in lieu of a nut, the thread length being greater than when used with a nut.

The distinguishing features of the cap-screw are due in part to its application in service, and in part to the early method of manufacture. The length of thread is suited to the maximum length of engagement of two diameters in cast iron, and the head is, especially in the larger sizes, distinctly smaller than in the case of the bolt.

ARTHUR BOOR:—What is the percentage of cap-screws used as compared with bolts?

MR. EHRMAN:—Up to and including the ½-in. diameter, both are used extensively. A cap-screw with a coarse thread is not intended for use with a nut, although to some extent it is so employed, thereby converting it virtually to a bolt. Used as a bolt, the head is smaller in diameter than the nut. The combination is perhaps a matter of convenience, as both components can be obtained from the dealer, and, of course, if the difference in diameter of head and nut is unimportant, the combination answers fairly well.

As to sizes larger than the ½-in. diameter, it has been the experience of some screw manufacturers that where bolts are desired, the regular S.A.E. bolt and nut is used and not the combination of cap-screw, threaded either coarse or fine, with a nut. Inasmuch as a large amount of this product is not sold direct, but through jobbers, it is possible that the combination may frequently be made of cap-screws, with coarse threads, and nuts, as S.A.E. bolts, with fine threads, are not carried in stock by jobbers extensively in the larger sizes.

MR. BOOR:—If the bolts predominate, the tendency must be to swing toward the bolts rather than the cap-screws.

MR. EHRMAN:—It seems to me it is a question of engineering practice on the one side and of difference of cost on the other. If good engineering practice indicates that the head and the nut should be of the same diameter. the Bolt Series is indicated; if, on the other hand, the slight advantage in economy is of more importance, the Cap-Screw Series is indicated. My idea is to bring this matter to the attention of the Society, so that, through it, its members may think and act collectively to the end that the Screw-Threads Division may have instructions as to how to proceed in the formulation of the new S.A.E. Series.

As introductory to the remarks that follow, may I express myself frankly by stating that the Society is deceiving itself a bit if it believes that it is working very closely to S.A.E. Standards for Bolts and Nuts.

I have taken advantage of opportunities to collect data relating to screw-thread products used by the industry and probably considered S.A.E. Standard. A canvass of the work in one department of a screw manufacturer showed that but 28 per cent was in strict accord with S.A.E. Standards. The other 72 per cent required making on special order. Had the 72 per cent of product been standard, partial shipments at least might have been made upon receipt of the orders, thereby obviating delay at the beginning of the rush season, as well as the inevitable telegraphic demands for impossible immediate shipments. As it was, the goods could not be shipped from stock, machines had to be set up specially, small batches of the product rushed through for shipment, and shipments in general delayed—all on account of very insignificant variations from the S.A.E. Standards.

A summary has been made of these irregularities. A number of examples, 170 to be exact, were taken at random from various orders that deviated to some slight extent from the S.A.E. Standards. I am submitting a classified tabulation of the irregularities that existed in this lot of examples. In many instances, several irregularities existed in the same piece.

Dimensions	Variations, In.	Number of Instances
Head Height	± 1/64	31
	± 1/32	2
Head Diameter	± 1/16	6
Body Length	± 1/64	1
	± 1/32	3
	± 1/16	10
	± 3/32	1
	± 1/8	18
Thread Length	± 1/32	5
	± 1/16	8
	± 3/32	4
	± 1/8	3
	± 5/32	2
	± 3/16	2
Shape of Point	Irregular	152
Measured Length	Irregular	125

It is obvious that products having any irregularity must be made on special order. The manufacturer does not know whether the customer has a definite reason for deviating from a standard and therefore has no alternative to manufacturing the product exactly according to the latter's specification. Such procedure occasions delay in the delivery of the product and unnecessary expense in its manufacture. Another factor demands attention. In case of breakage, wear or loss in use, the slightly irregular product is usually replaced by a standard product kept in stock at service-stations and garages. Obviously, if the repair is satisfactory, no reason exists why standard products should not have been used in the first place. On the other hand, if the deviation from standard is necessary, due to design, it seems that it would be the wise course, wherever possible, to modify the design so that standard screw products could be used, in this way providing for satisfactory replacements by standard products.

One of the reasons for presenting this situation is to afford the industries represented in the Society membership an opportunity to come to some agreement as to minor details such as those just noted, in connection with the work of a Subcommittee of the main Sectional Committee on Bolts, Nuts and Rivets. The members of the Screw-Threads Division should receive instructions from the members of the Society to the end that those details entering into the proposed standard may be satisfactory to the Society. The opportunity for easy revision is past, owing to the establishing of National standards under the rules of procedure of the American Engineering Standards Committee. The importance of definite expressions on the part of the members of the Society, in order that those representing it on the Sectional Committee may be fully informed, is clear. The matters on which instructions will be asked are:

Usable length of thread for bolts, intended for use with nuts

Length of thread for cap-screws, for engagement in holes tapped in cast iron and other materials softer than steel

Shape of point, whether oval or flat and chamfered

Measured length of screw or bolt, whether including or excluding oval or chamfer of point

In the present S.A.E. Standard, the usable length of thread for bolts is $1\frac{1}{2}\ D + \frac{1}{4}$ in.,[2] where D is the bolt diameter. It has been considered good practice to thread cap-screws, with coarse pitches, $2\ D + \frac{1}{4}$ in.

The present standard, for both S.A.E. bolts and coarse-thread cap-screws, calls for an oval point. The measured lengths of the S.A.E. bolts do not include the oval, on account of the extensive practice of assembling the bolts with nuts. The measured length of the coarse-thread cap-screw includes the oval of the point, because this product is used mainly in tapped holes other than those of nuts.

Some consumers specify flat-and-chamfered points. Properly proportioned, either point should afford protection to the partial thread at the end of the bolt. With the flat-and-chamfered point, the measured length of the bolt may be to

[2] More exactly, the length interval between two consecutive lengths of bolt.

the extreme end without reducing the effective length of engagement, which is not the case where the point is rounded sufficiently to prevent a wiry end-thread. The flat-and-chamfered point also presents a neater appearance when flush with the top of the nut than does the oval point.

W. E. GOSSLING:—Is the length, or depth, of the chamfered section the same as the depth of the oval section?

MR. EHRMAN:—No. Good practice indicates a chamfer angle of from 30 to 40 deg., preferably 35 deg., with a line normal to the axis. A chamfer slightly more than that of the thread slope, 30 deg., avoids the formation of a wiry edge by the half-thread at the end. To accomplish this result an oval point should have a radius equal to or slightly less than the diameter of the bolt. If the bolt end is flat and chamfered, less thread is lost than if the end of the bolt is oval. This is especially true in the larger sizes, as the oval is a function of the diameter of the bolt and not of the pitch of the thread. The length of the chamfer would be less on a screw having fine threads than on a cap-screw having coarse threads, as the chamfer need extend only to the root of the thread. As the length of the chamfer, measured parallel to the axis of the screw, need be but slightly more than one-half the pitch of the thread, the projection of the oval of the point would be greater in proportion for a fine, or S.A.E. threaded bolt than for a coarse, United States Standard, threaded bolt, measured in terms of the thread.

W. R. STRICKLAND:—I believe, in view of this situation, that the Society should circularize the industry, to get some information on this subject before the Sectional Committee acts and not wait until the Committee acts to consider it.

MR. EHRMAN:—To let the matter wait until the Committee acts would amount to nothing more than a post mortem examination.

MR. STRICKLAND:—I move that the suggestions that have been made by Mr. Ehrman, in connection with the prospective action of the Sectional Committee, be made the basis of a questionnaire to the members of the Society and the industry.

[The motion was seconded.]

MR. GOSSLING:—I propose an amendment to the motion, to the effect that the variations in current practice from the S.A.E. Standards, as presented by Mr. Ehrman, be included in the questionnaire to show how far the prevalent practice is from the S.A.E. Standard.

MR. STRICKLAND:—I am willing to include that in the motion.

CHAIRMAN MANLY:—I think we all appreciate very greatly Mr. Ehrman's work on this matter. I wish that in some way we could get all the members of the Society who are qualified to speak on the subject to give their best attention to the questionnaire when it is sent out. I have been pretty closely identified with this screw-thread work for many years. The greatest difficulty that has been encountered in it is that very few people in any one organization thoroughly understand the whole proposition, and unless a proper length of time is given to those people to make a thorough study of the proposition, they will not be able to give real criticism and suggestions on any recommendation. The screw-thread subject is very complicated. It has many factors. I therefore think that it would not be amiss if in this motion, as an action of the Standards Committee, we couple the request that the various companies who are circularized recognize the importance of this matter to them in both an engineering and a financial way, and see that the proper men in their organizations assist in securing the data requisite in service to the industry in threshing out the problems that Mr. Ehrman has so ably presented.

[The motion was carried unanimously.]

As a result of the action taken at the Standards Committee Meeting, as reported above, a questionnaire is being sent to automotive manufacturers to determine the consensus of opinion of the industry regarding the details mentioned by Mr. Ehrman. This information will be submitted to the Sectional Committee and will be used by the Screw-Threads Division members as a basis for their action in approving the report of the Sectional Committee when it is referred to them by the Council of the Society in accordance with Society procedure is approving reports presented by sectional committees of the American Engineering Standards Committee.

TENTATIVE CODE FOR TESTING TAXIMETERS

FOR the last 2 years the Bureau of Standards has been studying the matter of proper test to be applied to taximeters, and the result of this study was given to the recent National Conference on Weights and Measures in a paper by R. W. Smith, of the Bureau, in which a detailed testing method was proposed including instructions relative to bench, wheel and road tests; inspection; sealing and the like. In addition the Conference considered and adopted a tentative code of specifications and tolerances for taximeters, setting forth the errors that are to be permitted and specifying the character of indications to be required. Provision is also to be made for suitably lighting the face of a taximeter at night, the rates for which the meter is adjusted are to be shown on the meter and the taximeter is to be so mounted that the passenger can read its indications while seated in the cab. A broad general provision is included to the effect that

> All taximeters and all mechanisms and devices designed to be attached thereto and used in connection therewith shall be of such design and construction and shall be so installed for use that they do not facilitate the perpetration of a fraud.

Some of the requirements of the code are designed to apply to all taximeters in use, while others are to be applied only to new equipment. The action of the Conference in adopting this tentative code of regulations has the effect of bringing before the weights and measures officials of the Country and the manufacturers and users of taximeters a definite set of requirements relative to these instruments for their consideration and study during the ensuing year. At the Conference that will be held next year it is expected that a final code on this subject will be adopted and recommended by the Conference for official promulgation by State and city weights and measures departments.

A. D. DORMAN

ANNOUNCEMENT is made of the death, on June 27, 1925, of A. D. Dorman, Western manager of the Union Drawn Steel Co., Beaver Falls, Pa., and president of the Steel Sales Corporation, Chicago, aged 58 years. He was born on June 3, 1867, at Wheatland, Pa., and received a common-school education.

In 1886 and 1887 he was connected with the Union Switch & Signal Co., Swissvale, Pa. From 1888 to 1895 he was engaged in installation and in sales activities for the Brush Electric Co., Cleveland, and subsequently was New York manager for the Adams Bagnall Electric Co. of Cleveland, from 1895 to 1897. He became manager of the Chicago district for the Union Drawn Steel Co., Beaver Falls, Pa., in 1897 and continued this connection until the time of his death, being also vice-president of the Charles G. Stevens Co., steel merchant, of Chicago, and president of the Steel Sales Corporation, also of Chicago.

Mr. Dorman specialized in steel used in the manufacture of automobiles. He was elected to Associate Member grade in the Society on Oct. 1, 1914.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

MOTOR-VEHICLE HEAD-LAMPS

Better Lamp Construction, Beam Control and Stricter Law Enforcement Needed

At present many motorists undoubtedly rush toward home before dark because they are dissatisfied with the road-illuminating conditions. The motorists are justified in this. An examination of about 400 cars at the Bureau of Standards some time ago indicated that the majority of headlights are not in the best condition, while many are nuisances.

Several years' work of the Society and of the Illuminating Engineering Society has made available specifications of laboratory tests for the approval of headlighting devices. These specifications, which have been approved by the American Engineering Standards Committee as a tentative American standard, are printed in the S.A.E. HANDBOOK. They are now being used by many of the States as a basis for approval of headlight devices. However, the voluntary adherence to these specifications on the part of motorists is not general.

In 1923, Dr. Clayton H. Sharp, chairman of the Illuminating Engineering Society's Committee on Motor-Vehicle Lighting, stated:

> The working-out of the problems of application of these rules and the enforcement of the laws is the main thing for the future. At the same time, there is a necessity for the existence of a technical committee of the Society to cover this matter. The art is an advancing one and new ideas and new devices are constantly being put forward and no one can say when a more or less radical alteration of our notions on the matter may be called for.

Much remains to be done before the full benefit available from the present regulations may be expected. Moreover, the whole problem is so complex and difficult that undivided attention on the part of manufacturers of motor cars and of head-lamp equipment is imperative.

MATHEMATICAL EXPRESSION OF ILLUMINATION

It has been emphasized frequently that much trouble is caused by poor material and workmanship, the greatest difficulties being due to misformed reflectors, sagging and misplaced lamp-filaments, loose lamp sockets and lack of rigidity of the head-lamp brackets.

Further, it is admitted by manufacturers that the phenomena pertaining to road illumination have received not nearly as much attention as has been devoted to researches in the field of thermodynamics. An efficient motor-car needs effective non-glaring head-lamps as much as or more than it needs a highly efficient engine. It cannot be pleaded that co-operation from scientists is either lacking or meager. Some excellent work has been done on the subject and deserves further elaboration. For instance, Dr. Arthur Koenig and Dr. Eugen Godhun[1] in some researches on the subject substantiate a mathematical relation that expresses the intensity of perception as a function of physically measurable magnitudes of irritation or excitation such as light. This work is of much interest inasmuch as in a problem as complicated as that under consideration a concise expression of the personal element is a great step toward the solution of the problem. For this reason we shall give in abstract the mathematics verified by the above-named authors. If e designates the magnitude of perception; r, magnitude of measurable irritation; r_o, excitation characteristic of the nerve; and K, a constant, then $\delta e = K\ [\delta r/(r + r_o)]$ which after integration reads $e = K \log (r + r_o) +$ constant. This expresses mathematically that the perception of objects by the eye follows a logarithmic scale.

P. W. Cobb[2] has pointed out that the discomfort and disturbance to vision caused by what is generally known as glare are not necessarily related to an actual impairment of vision, but that it is well established that the ability of the eye to discern detail in any object is much reduced if the object is viewed when it is in the neighborhood of a very much brighter object, glare by simultaneous contrast, or immediately after looking at a much brighter object, glare by successive contrast. This reduction is greater, (*a*) the greater the brightness ratio between the two objects is and (*b*) the less their angular separation is.

ELEMENTS OF SATISFACTORY ILLUMINATION

In the 1916-1917 report of the Illuminating Engineering Society's Committee on Automobile Head-Lamps, an effort was made to define satisfactory illumination. It was stated that the brightness of the roadway should be maximum over an oblong area centering, as seen by the driver, about 100 ft. ahead of the car and extending nearly the width of the roadway from 50 to 100 ft. ahead of the vehicle; and, furthermore, that from this area of maximum brightness the brightness on the roadway should shade off gradually, laterally and in the extreme distance.

From the point of view of the person approached, ideal headlighting is that which produces no blinding glare in passing. This condition, it has been stated, requires that the illuminating beam shall not at any point shine in his eyes and that at no point in passing shall the total light entering his eyes from any given direction be more than equivalent to that from a source of, say, 100 cp. for a length of time greater than ½ sec.

Since the time of this 1916-1917 report, it has been agreed that under ordinary conditions a light of 100 cp. is troublesome only to the most sensitive. Many street-lamps are above 100 cp. and are considered good illumination. From an average of 50 observers, it was found through extensive tests that about 250 cp. can be tolerated without serious interference.

From tests, it was further established that 800 cp. is about the highest value accepted by any of the observers. For this reason, in the photometric test-chart of the Illuminating Engineering Society and the Society of Automotive Engineers, at the accepted glare-point D the maximum of 800 cp. is specified.

SPRING DEFLECTION AND UNEVENNESS OF ROAD

A head-lamp can comform to these requirements only when it is on a smooth level road or one of uniform grade. New problems arise when vehicles approach each other while going over the crest of a hill. Reflection from wet streets, curves, the presence of obstacles or holes, turns, atmospheric conditions and other factors have considerable influence on the whole problem. Due to improperly designed springs and balloon tires, cars bob up and down, throwing flashes of light into pedestrians' and approaching drivers' eyes. One factor that has been given attention is the upward elevation of head-lamp beams when the rear springs are deflected by load or unevenness of the road. A report made by the National Lamp Works and the Guide Motor Lamp Mfg. Co., of

[1] See *Sitzungsberichte der Koeniglich Preussischen Akademie der Wissenschaften zu Berlin*, vol. 2, p. 917.
[2] See *American Journal of Physiology*, vol. 29, p. 97.

Cleveland, contains a summary of results obtained in a survey conducted to determine the relation between the loading of a car and the deflection of its head-lamp beams. To measure the deflection, a transit was placed on the running-board of the car, with the telescope parallel to the axis of the car and leveled with the car standing empty; then a load of 500 lb. was put in the rear of the car, and the telescope re-leveled. The angular displacement was, of course, read on the arc of the transit.

Live load was used for all of the observations. Cars were taken at random, in whatever condition they happened to be found, to record as representative conditions as practicable. Readings were taken on about 275 cars. From the data so obtained, Table 1 has been derived as a suggestion for loading allowances at 25 ft. ahead of the car based on actual deflection and wheel-base.

TABLE 1—ALLOWANCES FOR DISPLACEMENT OF HEAD-LAMP BEAMS AT A POINT 25 FT. AHEAD OF CAR DUE TO THE LOAD, DEG.

Wheelbase, in.	100-110	110-120	120-130	130-140
Phaeton	6	5	4	3
Sedan	5	4	3	2
Coupe	4	3	2	1
Roadster	3	2	2	1

The Present Situation

Why do not automobile builders advertise that their cars are equipped with good lights? Maximum speed, acceleration, riding-comfort, appearance, good braking and other factors are advertised. It would be well for car builders to state definitely how well their head-lamps are built, whether they can be adjusted easily and how long they will remain adjusted.

The present condition is due to the fact that it is not known how much light is really needed for comfortable driving and how much of this light can be tolerated by an eye in the darkness, bearing in mind that the contrast sensibility of an eye is not a simple linear function of the brightness but that under certain conditions it diminishes very rapidly.

It is planned that a committee, organized under the auspices of the Society, shall make a further study of the head-lamp problem.

A list of articles and books that are pertinent to the general subject, which was furnished by Dr. C. E. K. Mees, director of research for the Eastman Kodak Co., is appended.

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Motor Transportation as a Passenger-Carrying Agency

By A. W. S. Herrington[1]

Washington Section Paper *Illustrated with* Diagrams

ABSTRACT

VEHICULAR-TRAFFIC congestion in large cities, the most suitable means for minimizing it and the economics of the motorcoach are among subjects treated. Quoting statistics, the author says that the total mileage of street railways in this Country has decreased in recent years; but he believes this is a healthful indication that the motor vehicle and the street car are adjusting themselves to their respective economic fields as transportation agencies.

Referring to the fact that every phase of American life has been affected by the greatly increased personal mobility afforded by the motor vehicle, it is emphasized that the many problems created by the rapid development of traffic volume must be analyzed and solved in a scientific manner, since final solutions of such complicated propositions can result only from calm, impartial and scientific deliberation. Although the author says that economists' studies regarding the saturation point for motor-vehicle consumption in this Country have been based largely upon estimates of the number of people who possess money enough to buy a motor car, he believes it more probable that some approach to a true estimation of a saturation point will be obtained from a proper estimate of the available road space in the Country upon which motor vehicles can be operated.

The motorcoach, especially the double-deck type, is mentioned as an exceptionally efficient vehicle for moving passengers in congested areas. If it proves to be impossible to increase the available road space to take care of traffic demands, the author feels that the only alternative is to increase the load factor of the vehicles operating in congested areas and that, unless this is done, property values in congested areas will decrease and business will migrate to other sections.

AS Elwood Haynes was driving his motor carriage about the streets of Kokomo, Ind., nearly 31 years ago, he little thought of the extent of the social, political and geographical upheaval that his vehicle was to initiate in our Country. He could hardly have visualized a new transportation medium that, due to its flexibility and mobility, would reach out and hew for itself a special niche in our transportation structure. Even today, many men cannot foresee that, inevitably, the motor vehicle as a passenger-carrying unit must take its proper place in our urban transportation-systems, and that eventually it must replace the car lines upon the congested streets of our cities. In isolated cases, this change has already been made. Within the next 5 years it will have reached proportions that few of us can now conceive.

Statistics show that the total mileage of street railways has decreased steadily year by year. That is a healthy indication that these two transportation agencies are adjusting themselves to their respective economic fields. The accomplishment of this adjustment will bring increased prosperity to both.

Of 21,000,000 automobiles and motor trucks in use in the world today, approximately 18,000,000 are in the United States. Every phase of our American life has been touched and affected by the greatly increased personal mobility that this new instrument of transportation has given to us. A rapid development of this character produces many problems, the solution of which lags behind their creation. These problems must be analyzed and handled in a scientific manner. We are living in a scientific age, and lasting solutions can only be the result of calm, impartial, scientific deliberation. Good management and scientific management are synonymous.

In a recent article Richard T. Grant, ex-president of the Chamber of Commerce of the United States of America, wrote:

> The force that originates methods and purposes, that gages the future and its requirements, brings together the equipment provided by the investors and the employe and marks out how results can be obtained that will fit the condition of next month or next year, the force that makes it possible to have something left from receipts after wages have been paid and after investors have been paid, is management.

The problems of the motor-transportation industry are so large and so far reaching in their possible effects upon the welfare of our Country, that there can be no room for passionate, ill conceived policies and governing laws. Motor transportation already has taken its place beside the older agencies of animals, water and rail. It already has attained a position in the industry larger than the other three combined.

Road Space as a Saturation-Point Determinant

Economists have long been looking for the elusive saturation point in the consumption of motor vehicles in this Country. Most of these studies have been based upon an estimate of the number of people who possess enough money to buy a car. Our telephone service is very cheap, but there are now more automobiles than there are telephones in the United States. It is more probable that some approach to a saturation point will be found in an estimate of the available road-space we have upon which to operate motor vehicles.

From Detroit resounds the slogan of the man who has contributed more than any other single person to this condition of affairs: "7000 more since yesterday." Assuming a 300-day year, and that each vehicle would occupy 10 ft. of road space, the year's production of this car alone, placed front to back with no space between, would represent a single line of traffic 3787 miles in length. If only two car-lengths were permitted for driving space and this line of vehicles was in motion, it would represent a line more than 11,000 miles long, or a line of cars four abreast from New York City to San Francisco.

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The automotive industry produced 3,629,237 passenger cars and 392,760 trucks in 1923. Allowing 12 ft. per passenger-car length and two car-lengths between each vehicle, this represents a line of traffic 26,744 miles long. Allowing 20 ft. per truck length and two truck-lengths between each vehicle, we would have a line of trucks 3900 miles long. Together they represent a single line of traffic 34,644 miles in length, or a moving line of cars and trucks 10 abreast from New York City to San Francisco. Compare the foregoing totals with the report of the Bureau of Public Roads on the status of Federal Aid Highway Construction as of March 31, 1925, which is stated in Table 1.

TABLE 1—STATUS OF FEDERAL-AID HIGHWAY CONSTRUCTION AS OF MARCH 31, 1925

Projects	Miles
Completed prior to July 1, 1924, (Fiscal Years 1917 to 1924)	34,453
Completed Since June 30, 1924	7,486
Under Construction	16,148
Approved for Construction in the Fiscal Year 1925	2,285
Total	25,919

In other words, according to Table 1 and the 1923 statistics, the production of the industry for one year, 1923, placed upon our roads a greater mileage of single-line moving-traffic than there were miles of Federal Aid Highway constructed from 1917 to 1925, or a period of 8 years. The increased mileage of roads planned in 1925 is a healthy indication that our Country is awake to the necessities of the motor-transportation problem.

Congested City Districts

These comparisons give but a rough idea of the congestion trend. We are more vividly reminded of it as we attempt to enter the more congested areas of city business-districts. For a long period the trend of our population has been to centralize. The recent emergency, with its acute housing shortage and a rapid rise and continued high level of building costs, has been responsible for it. The mobility provided by this new form of transportation has not, up to this time, been sufficient to stem the tide. The pendulum is swinging backward, however, and our congested business and residence districts are beginning to force people to live farther and farther away from the congested areas. The chain store and its successful organization is based upon this decentralization of population.

Without question a large proportion of the congestion that is now found in our business centers is caused by the attempt to mix motor vehicles and rail-cars as passenger-carrying mediums. Our present-day city-planners may well turn back again to the Old World to the Khyber Pass leading from Afghanistan to India. Here over the ancient route that has resounded to the tramp of the hosts of Darius the Great, Alexander the Great, Jenghiz Khan, Timur the Lame and Baber, the British military authorities have found it necessary to segregate the forms of transportation using the pass. Through the Khyber Pass with its strategic military and political position, three parallel highways now extend. The upper one is for camel caravans, which sometimes are 15 miles in length. The middle road is for motor trucks and moving troops. The lower road is reserved for the faster moving vehicles, such as military staff-cars and motorcycles. It is this mixture of traffic of different speed capabilities that is responsible for much of our present congestion. The street car can no longer take advantage of its speed over long distances, due to stopping at every block and being confined to the center of the road where it delays and is, in turn, delayed by congestion caused by other vehicles. This matter has become serious in our larger cities.

Transportation by Motorcoach

Our studies demonstrate very clearly that the motorcoach, especially the double-decked type, is an exceptionally efficient vehicle for moving passengers in congested areas. It is only within the last 2 or 3 years that city planners have given much attention to this new form of transportation, and they seem to have ignored entirely up to this time, the individually owned and operated passenger car as a transportation medium.

Fig. 1 shows the relative areas and seating capacities of a street car, a motorcoach and an average passenger car, for comparative purposes. Based upon the data in Fig. 1, it is shown in Fig. 2 that the motorcoach is the most effective and the automobile the least, when the number of square feet of road space per passenger carried is considered. In this comparison, the rails that confine the street car to the center of the street constitute an obstruction factor. Fig. 3 illustrates an increase in the carrying capacity of streets when motorcoaches are operated during rush-hour periods.

Taking a city geographically bounded by water as New York City is, its streets already loaded to the saturation point with vehicles of all descriptions, little relief is to be found in the provision of more arteries for traffic flow into and out of the city. Space in the city itself is the most crying need. If by a magic wave of a wand the available street space of New York City could be increased 100 per cent over night, this space would be occupied immediately by those who own vehicles and for whom the only present deterrent is the congested condition.

The "no parking," "one-way street" and "no left turns" regulations are obnoxious to our inborn love of freedom. They are a necessary means however to permit the solution to catch up with the problem, and the indications can be seen plainly that regulation must sooner or later prescribe the types of vehicle that may move in certain areas at certain times. It is only the proper education of public opinion to the necessity of these regulations which has deterred present political powers from putting them into effect.

It will be impossible economically to change congested areas within a short period of time to such an extent that traffic problems will disappear. The only alternative is to use our available space more effectively until other factors in the problem balance out.

Increased Vehicle Load-Factors

The necessity for increasing vehicle load-factors has been apparent in New York City, where there has been considerable sentiment against cruising taxicabs. Police regulation has sought to control this practice. I do not know whether this regulation is the answer to an hysterical demand upon the part of a few influential private-automboile owners or whether any analysis of the ratio of cruising to loaded miles of taxicabs was made; but it is evident that this ratio must be a low one or the business of taxicab operation could not be profitable, considering the low rates. If this ratio is low, it would seem to be an ill-conceived regulation that would bar such a transportation vehicle from the streets. It is impossible to conceive that the average taxicab has less passenger-revenue miles in its evening cruising for business than

the high-priced town-car that rolls down from the Upper Eighties into the Roaring Forties and occupies valuable space there until the opera is over.

The time is not far distant, in my opinion, when certain sections of cities like New York will be closed entirely to the privately owned and operated automobile. An analysis of present taxicab mileage-rates indicates that they are equally as cheap and, in the cases of an expensive-car comparison where depreciation is high, they are cheaper than the cost per mile of operating a private car. Many residents of our larger cities now have found it unnecessary and inadvisable to own their own cars. They depend upon the equally flexible and economical taxicab as a means of transportation in those areas.

Department stores operating in metropolitan areas maintain their own delivery systems. It is not uncommon to see the delivery trucks of three or four companies bringing, each in turn, a small package to the same

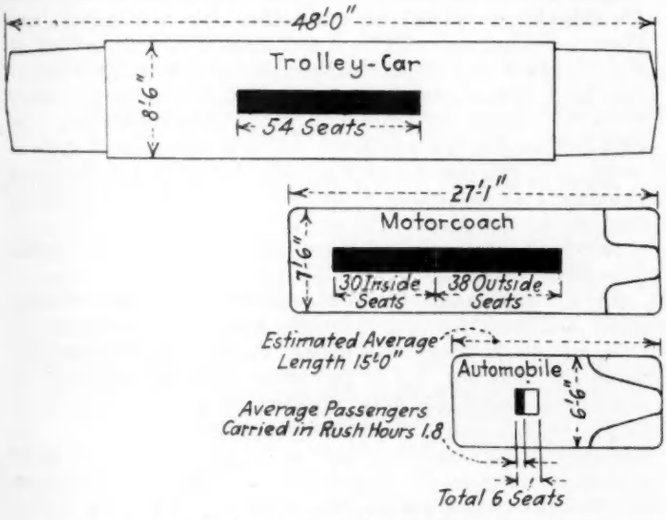

FIG. 1—COMPARATIVE SEATING CAPACITY
The Relative Areas and Seating Capacities of a Trolley-Car, a Motorcoach and an Average Passenger-Car Are Presented

address. It would seem that a single delivery company properly organized and equipped could both reduce the delivery cost to the department store and increase the speed of delivery to the customer.

If it is impossible to increase the available road-space to take care of the traffic, only one other alternative exists; it is to increase the load factor of the vehicles operating in the congested area. Unless this is done, property values in that area will drop and business will migrate to other sections of the city where relief can be obtained. The trolley car operating upon steel rails in the center of the street, holding up all traffic behind it, is one vehicle that must be eliminated from our business districts and the more efficient and flexible motorcoach service substituted. In New York City, the movement of retail business from Broadway to Fifth Avenue and, in Chicago, a similar movement from the loop district out to South Michigan Boulevard, are good examples. Can anyone imagine putting trolley cars on the many narrow streets of London to carry the volume of traffic the London General Omnibus handles?

MOTORCOACHES VERSUS STREET CARS

Many street-car companies are fighting the motorcoach by every means in their power. Others more progressive are entering the motorcoach-operating field. Certainly

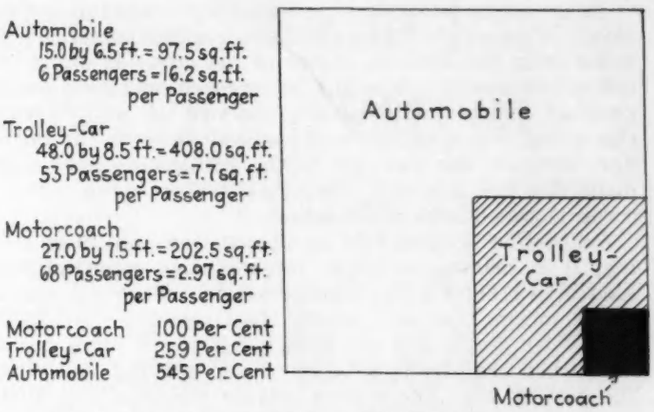
Automobile
15.0 by 6.5 ft. = 97.5 sq. ft.
6 Passengers = 16.2 sq. ft. per Passenger
Trolley-Car
48.0 by 8.5 ft. = 408.0 sq. ft.
53 Passengers = 7.7 sq. ft. per Passenger
Motorcoach
27.0 by 7.5 ft. = 202.5 sq. ft.
68 Passengers = 2.97 sq. ft. per Passenger
Motorcoach 100 Per Cent
Trolley-Car 259 Per Cent
Automobile 545 Per Cent
Automobile
Trolley-Car
Motorcoach

FIG. 2—COMPARATIVE AREA OF ROAD SPACE PER PASSENGER
Based upon the Data Given in Fig. 1, the Above Diagram Shows That the Motorcoach Is the Most Effective and the Automobile the Least, When the Number of Square Feet of Road Space per Passenger Carried Is Considered. In This Comparison, the Rails That Confine the Trolley-Car to the Center of the Street Constitute an Obstruction Factor

it is the street-railway company that has the integrity, experience and ability to handle motorcoach operation successfully. Many have been deluding themselves into believing that the motorcoach is a good feeder to the outlying ends of their rail-transportation system; whereas, the economic place for the motorcoach is as a transportation medium in the congested areas feeding to traffic out to those points where the greater speed of the railed system begins to give it the advantage.

In the city of Baltimore, the United Railway Company is operating a motorcoach line up Charles Street. This is the main business street of the city and extends into the best residential district. In addition to this line the company operates a number of other feeder lines to the outlying ends of its rail systems. The Charles Street line, as shown by a recent financial statement, operated for the year at a satisfactory profit in spite of the fact that it goes into the most congested part of the city and is in direct competition with a trolley car line which, for part of the route, is upon the same street and for the remainder of the route is only one block away. This profit however, was totally eaten up for the year in meeting the deficit caused by the outlying feeder lines.

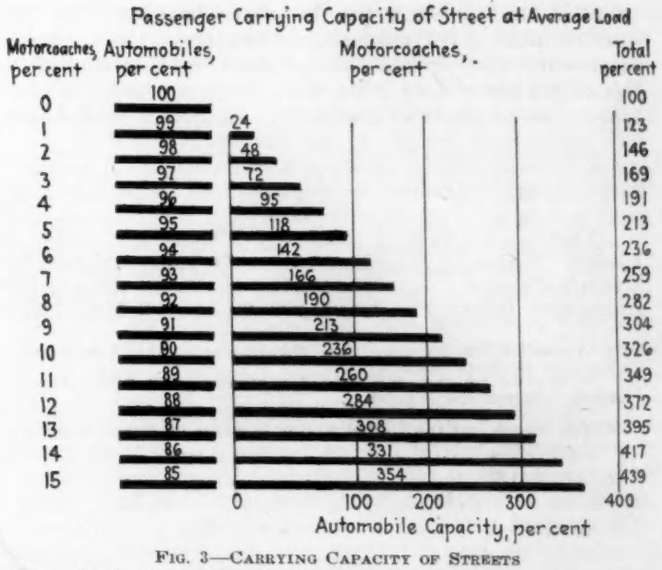

FIG. 3—CARRYING CAPACITY OF STREETS
The Chart Illustrates the Increase in the Passenger-Carrying Capacity of Streets When Motorcoaches Are Operated during Rush-Hour Periods

In the city of Cleveland, a high-speed rail-transportation line serves the Shaker Heights residential section, 7 miles from the business center of the city. It would be difficult to conceive how any motorcoach operation could possibly compete with the rail service in that form. Operating over a private right-of-way through the business district, the run out to the residential section is made in a few minutes. On a local trolley car or motorcoach it would take much longer.

Congestion is spreading our population and, in so doing, it is making as many remunerative opportunities for rail as it is for motor transportation. The motorcoach is the means that will handle the congested short-haul down-town traffic and will feed it out to the more rapid interurban rail-transportation lines serving outlying districts at high speed over private rights-of-way that are not situated upon streets designed for the use of other forms of transportation. No competition exists and no competition can exist between these two forms of passenger transportation.

In many communities ill-conceived, hysterical and lobbied-interest laws are to be found aimed at the new motor-transportation industry. Most of these laws have been passed for the alleged protection of capital invested in rail-transportation agencies. This capital is safer today than it ever was in the history of our Country's wonderful commercial growth. It will be safe just so long as the officers responsible for the policies in connection with its investment are wide awake to the rapidly moving business conditions in our communities. If they are not on their toes and cannot keep abreast of these demands, laws alone will not save them. It is not possible to legislate an economically sound industry out of business. Such resistance may retard its progress but, in this age of scientific development, that which is basically and economically sound will prevail.

Proper Utilization of Tax Monies

By the use of automobiles the riding public has been educated to the flexibility, quietness and easy riding of the motor-vehicle form of transportation. It wants that form in preference to the noisy, congested hard-riding steel-rail form that offers nothing in the way of an improvement over the same ride of 15 years ago. But little progress has been made in rail transportation and conditions in that industry are far from healthy. The tax burdens upon rail transportation are great, but the automotive industry within the last year has contributed to the public tax coffers more than the steam and the electric-railway industries combined. In spite of this heavy burden, the automotive industry has prospered. The tax contributions of the three industries for the last 3 years are given in Table 2.

TABLE 2—TAX CONTRIBUTIONS OF THREE INDUSTRIES FOR THREE YEARS

Year	1922	1923	1924
Electric Railways[2]	$64,788,315	$65,000,000[a]	$66,500,000[b]
Steam Railroads[3]	308,145,247	336,399,600	350,000,000[a]
Automotive Industry[4]	331,901,209	471,548,000	555,026,548

[2] Compiled by the statistical department of the American Electric Railway Association.
[3] Compiled by the statistical department of *Railway Age*, from Government sources.
[4] Statistics compiled by the National Automobile Chamber of Commerce and the United States Bureaus of Public Roads and Internal Revenue.
[a] Estimated minimum.
[b] Estimated.

In 1924, the automotive industry paid 33 1/3 per cent more taxes than did the electric railways and the steam railroads combined. A recent investigator has gone further into these figures. He has developed the facts that the automotive industry is the most heavily taxed large industry in the United States, and that the increase in taxation on the automotive industry has been more rapid and greater than that of any other large industry in the United States.

One of the pet arguments of the near-sighted rail protagonist who imagines that the motorcoach is a competitor is that this new transportation medium contributes nothing to the maintenance of the right-of-way upon which it operates. Let us examine a few cold facts pertaining to the operation of the gasoline tax that is upon the statute books of 43 States and the District of Columbia. As a matter of principle, let us admit that the highways should be maintained by those who use them. Regardless of queer and unforeseen workings of the gasoline tax, let us further admit that it apportions this load upon the various highway users more equitably than any form of maintenance tax so far devised. Is this tax in its present form of 1, 2 and 3 and even 5 cents per gal. sufficient for this highway-maintenance program? If we examine the records we find apparently that it is; and that, further, it provides a healthy surplus which our State politicians are converting to "general-fund" use.

In Pennsylvania, in 1924, $9,089,541 was collected from a 2 cent per gal. gasoline tax, and $6,800,000 of this, or more than two-thirds, went with the general fund for use for other purposes than highways. In Maryland, $1,588,422 was collected, of which $476,000 or 20 per cent failed to reach the highway fund, and no one has ever criticized the State of Maryland for failure to care for its excellent highways. In Texas, $970,000 or 25 per cent out of $3,892,769 went into the "free school fund." North Dakota puts all of her gasoline tax into the general fund. South Carolina puts 33 1/3 per cent into the general fund. Part of this money is being used in that State to retire old railroad bonds.

Considerations for the Future

The chaotic period through which we are passing is the readjustment period brought about by this relatively new form of transportation. It must and will find its place in the properly coordinated transportation structures of our Country. It provides a new transportation sensation that the riding public likes, and it is a basic sales principle that it is easy to sell that which the public wants. The prosperity of our Country has, as one of the rocks in its foundation, a highly developed transportation system.

An undreamed-of prosperity lies ahead for those executives of all transportation agencies who have sufficient vision to allocate and expand their various activities in the particular field in which they can serve the public most effectively. The extent of this prosperity is dependent upon their ability to profit by the lessons of the past, and to view the future with a calm, scientific, constructive and progressive spirit.

Operation and Advantages of the Piecework Automobile Service-System

By William G. Gow[1]

Service Meeting Paper

ABSTRACT

THE whole period of automotive service is divided into three eras; first, that of lack of system and order; second, the constructive era of the flat-rate system, and third, the era of the piecework system. The first is dismissed as unworthy of much comment. The second marked a forward step, definite prices for specific repair jobs, the customer being charged on the basis of time plus materials used, the workman receiving from 40 to 60 per cent of the hourly rate charged to the customer. Under this plan, there was considerable idle time, the station barely managed to make income equal expenses, mechanics were dissatisfied.

Under the piecework method, the customer is charged a definite price for the work, which charge covers the mechanic's labor, all parts and materials used and a percentage for overhead and profit. The mechanic receives a fixed amount for his work regardless of the time spent on it, and this is a powerful incentive. The mechanic guarantees his work so that if any job comes back because of poor work, he is required to do the work well without charge. The service-station guarantees each job to the customer for 30 days. Consequently, although the men do in 8 hr. work that formerly took 14 hr., the work is well done. The men are not paid for idle time and there are few idle hours, because fewer men are employed and more jobs are turned out by the station. Comparative records show that whereas in January, 1922, a force of 60 mechanics performed 284 jobs for which a total of $10,000 was charged to customers, in the same month of 1924 a force of 16 mechanics did 584 jobs aggregating $20,000. If a man has any spare time, it is used in improving his tools, helping other men, reading instructions or having a smoke in a room provided for the purpose. No more men are hired so long as the force can turn out all work taken in, hence they do their utmost to get work well finished. It has been found that neither foremen nor helpers are needed.

The advantages of the piecework system are that (*a*) a job can be promised to the customer at a definite time, (*b*) a car will not be in the service-station for 3 or 4 days, (*c*) each job is guaranteed for 30 days, (*d*) the best men make the most money, (*e*) the customers are satisfied, (*f*) the men are satisfied and (*g*) the service-stations are making money.

AS a result of my contact with and knowledge acquired of the automotive service industry in the last 15 years, I can plainly discern three distinct eras: first, the slipshod era, or the epoch of the lack of system and order; second, the constructive period, or the epoch of the flat-rate system, and third, and incidentally the most economical and profitable, the era of piecework, or the epoch of satisfactory service that pays.

No time need be spent upon comment about the first era. Everyone knows how the service-stations were conducted during that period. They were looked down upon by the public and by the automobile companies themselves. They were considered necessary evils and were usually run at a great loss to the dealers and the factories.

The second era, the time of the flat-rate system, marked a step forward. Progress was being made within the industry; a great many stations inaugurated systems of some kind for the handling of repair work; working conditions were made comparatively better for the mechanics and some shop tools appeared on the market which were adopted readily. During this period a great many stations, and some factories also, worked out plans whereby prices could be given in advance to customers for work that was to be performed on their cars. However, the mechanics worked upon an hourly rate and, consequently, when they were not busy, they had, and hated, what is commonly known as *idle hours*. This was the period in which a few of the stations managed to break even financially at the end of the year, but for the most part it was the old story of finishing in red ink.

How the Piecework System Works

Now we approach the period of piecework, or what might be termed the era of the service manager's paradise. It is the era of system, routine, order, no idle time, no overtime, intelligent management, one price to the customer, one price to the mechanic, good working conditions and better-paid productive and non-productive help. In brief, it is the era of *buying labor by the job and selling it by the job*. Piecework compensation to the mechanics is the logical step after the flat-rate system. The piecework system is a system of paying mechanics by the job rather than by the hour.

Under the time-and-material method of charging for repairs, the car-owner pays for labor by the hour and the shop pays the mechanics for their labor by the hour. The mechanic receives from 40 to 60 per cent of the hourly rate charged to the customer and the difference goes to pay for overhead expense, mechanics' idle time, which cannot be charged for directly, "come-back" jobs and a variety of other expenses.

With a piecework charge, in which is included the price of the material used on every operation down to the last cotter-pin, the customer is charged a specific price for the complete operation. From this amount a fixed price is given to the mechanic, a like amount for overhead, an allowance for the new parts used and an amount to cover the incidentals needed to complete the job, such as cotter-pins, rags and gasoline. The mechanic's price is fixed from experience without regard to the time it actually takes him to perform the work, but the average operation shows that a good mechanic can cut this standard time allowance almost in half and this means that a good man can accomplish 14 standard hr. work in an 8-hr. day. This is an incentive to work. The mechanic must bear in mind, at all times, that his work is guaranteed for a period of 30 days. The contract between the service-station and the mechanic is lived-up to to the letter. This is necessary because a written guarantee of the work for that length of time

[1] General service manager, Studebaker Sales Co., Newark, N. J.

is given to the customer on his invoice. The only case in which the mechanic is not held responsible is that in which the part installed proves defective; the charge is then assumed by the service-station. The mechanic is not paid for idle hours. This time is spent by the men in improving their tools, reading instructions, helping another man or having a smoke in the room provided for that purpose.

Income Doubled With 74 Per Cent Fewer Men

That service operations can be performed in a quick, workmanlike manner is proved by our records for the months of January, 1922 and 1924. In the former month, 284 jobs were performed by a force of 60 mechanics and the charges for these jobs amounted to $10,000. In January, 1924, 584 jobs were completed by a force of 16 mechanics and the aggregate price of these jobs was $20,000. It may be stated here that there was a vast difference in the amount of work taken in during the same month in the two years, which is accounted for by the fact that in 1924 we used advertising to stimulate our business.

The men on a small force are promised that no more men will be hired if the force can turn out all of the work that is taken in, and naturally they will do their utmost to get the work out rather than have more men around because, with more men, when work is somewhat slack, which occurs usually at the end of the week, the individual man will not receive so much work and, consequently, not so much money as when fewer men are employed.

A larger volume of work can be handled by the shop because each job is completed more quickly than formerly and another can take its place; more cars mean more work, and more work means more money. The incentive of a larger pay-envelope is ever present. Men who were working 3 years ago for $30, $35 and $40 a week are receiving now $40, $50 and $60. The average wage rate at that time was approximately 65 cents per hr., whereas now, under piecework, the rate is $1.10.

Work Guaranteed by Shop and Men

The more important advantages of the system which are derived directly from the saving in time are that the tester can, by consulting the shop superintendent, promise that a job will be finished at a definite time and knows that a job that has just been driven away by a customer is guaranteed for 30 days and that, if it should come back within that time, it will be done over by the mechanic free of charge if the workmanship does not stand-up. The only work for which no guarantee is given is the taking down, examining and reassembling of a unit when an examination is made, the result reported to the owner and no additional work is ordered. In that case there can be nothing to guarantee and the mechanic is paid merely for stripping, examining and replacing the unit.

Another excellent feature of the system is that a customer can bring his car in to have certain work done on it and know, from previous experience, that it will not be in the service-station for 3 or 4 days. Men nowadays buy cars for business use, and to have them stand in a service-station longer than is necessary may cause the owners some business losses.

We found that the adoption of the piecework system was not a very costly matter but it takes considerable time. The only obstacle that we encountered was that the men were somewhat skeptical at first that they would make as much money as they did under the hourly rate, but 1 month's trial proved to their satisfaction that they could make as much and more.

No Foremen or Helpers Needed

It was discovered, also, that foremen were unnecessary, as the work was given a thorough test by the tester and each job was, in addition, guaranteed by the mechanic; any work improperly done would be detected before the car was returned to the owner. The fact was impressed upon the men, too, that when doing a job, it would be to their advantage to do little things on the car that they noticed were required but that were not on the written order. They were told that customers would appreciate service of that kind and would continue to patronize the station even in the winter.

Another thing that we do not have is helpers. Every man is a mechanic. It is a common occurrence, however, to see one man helping another, because a time may come when the first man may want help himself and he can expect a return of the service.

Prices charged to customers were arrived at by a careful check-up on the time used previously on jobs and also by time studies, striking a general average of the results. If it was found that too much was being charged for a job, we reduced the price, but only after obtaining the consent of the mechanic and only in cases in which the men could make the present average hourly rate.

The best men in our shops make the most money and the mediocre men average a very fair rate. If a man does not make money it is his own fault, and if he does not improve after he has been with us for a reasonable time, we let him go. We cannot afford to allow a man to waste his own time because he is wasting ours as well.

Results show that the piecework system is good, safe and profitable, for three reasons: (*a*) our customers are satisfied, as I have found by personal contact and as shown by letters; (*b*) we are making money, as proved by our monthly balance sheets, and (*c*) our mechanics are satisfied and happy, which I know because the men have told me that if we tried to go back to the hourly-rate system every one of them would quit work. However, I did not need this assurance; if it were ever found necessary to go back to the hourly rate, I would be the first one to resign.

PRICE-LEVEL AND INCOME

THE income tax figures for 1923, following upon those of the years since 1919, effectually demonstrate that throughout the society of the United States prices and remunerations of all kinds are now established at such a level that the population as a whole regularly enjoys incomes which, measured in terms of money, are fully twice as great as those obtaining before the war. The economic significance of this fact is self-evident.—A. R. Marsh in *Economic World*.

Reduction of Automobile Accidents by Use of Psychological Tests

By A. J. Snow[1]

Semi-Annual Meeting Paper *Illustrated with* Charts

ABSTRACT

An individual who is mentally subnormal, emotionally unstable and on the verge of hysteria or who lacks moral responsibility, is potentially unsafe as a driver of an automobile and is certain to be involved in an accident sooner or later. He may be a skilful driver under normal conditions but he has not the mental capacity to use good judgment in unusual situations. In an emergency an emotionally unstable person may become hysterical and entirely inactive, and it is only a matter of time when the reckless driver will misjudge distance or speed and get into trouble. Although public education in highway safety measures is of great value, so far as normal individuals are concerned, it cannot remake the nature of the person who is mentally incompetent, emotionally unstable or morally irresponsible. Only a relatively small reduction in accidents can be accomplished by education and traffic regulations. It was discovered during the war that many of the men drafted for service were mentally subnormal. A great many such individuals are at liberty today, are employed in industry and may be driving motor vehicles.

One of the surest ways of reducing accidents is to make certain that any person who is allowed to operate a motor vehicle on the highways is of normal intelligence, has normal emotional stability and possesses fair moral foresight and caution. It is now possible, by the use of psychological tests, to detect with a great degree of certainty the undesirable type of driver. Since the first of this year the Yellow Cab Co. has been applying a series of such tests to all applicants for taxicab drivers' jobs in Chicago, where 8000 drivers have been tested. This includes 3000 men now employed by the company out of a total of 6000 employed there. Twenty-one per cent of all applicants since Jan. 1 have been rejected because of failure to pass the tests. The same method of selecting drivers is now in use by the Yellow Cab companies in Louisville, Ky.; Cleveland, Pittsburgh, South Bend, Ind.; Toledo and Omaha, Neb.

The method includes a physical examination and a series of tests of intelligence, emotional stability and carefulness. The apparatus used and the methods followed in making these tests are described.

To prove the value of the tests, a record was kept for 10 weeks of 311 applicants who took them. A group of 34 classified as unsatisfactory, of whom only 26 started to work and 5 dropped out, had 26 accidents due to carelessness or gross negligence, an average of one accident per man; 17 men, or 64 per cent, were involved in the accidents, and 10 men, or 38 per cent, had more than two accidents. In the "satisfactory" group were 258 men, of whom 10 did not start work and 50 dropped out, 84, or 33 per cent, had accidents due to carelessness or negligence; 32, or 12 per cent, had more than two accidents, and the average number of accidents per man was one-fifth. Thus, only 20 per cent as many accidents per man occurred in the group that passed the tests as in the group that the tests showed to be undesirable.

Only by such a process of elimination of unsafe drivers will it be possible to control the automobile accident hazard. Massachusetts has had in operation for a year a law that permits the license bureau to refuse operators' licenses to persons found to be mentally defective, and a great reduction in accidents during the year has been recorded. In time, similar measures will be introduced all over the world.

[1] Director of psychological research, Yellow Cab Co., Chicago.

If an individual driving an automobile is mentally incompetent he is certain to have an accident sooner or later and, although education in measures for public safety is of great value, all of the safety talks, posters and safety "weeks" will not remake the nature of the mental incompetent and make him a safe pilot of a powerful vehicle. An imbecile, a moron, an emotionally unstable individual who is always on the verge of hysteria or one who lacks moral responsibility and reveals this defect by his carelessness and recklessness is by his very nature potentially unsafe as an automobile driver. He may be an excellent and skilful driver under normal conditions but if he is an imbecile or a moron he has not the mental capacity to use good judgment in an unusual situation. If he be emotionally unstable he is very likely to become entirely inactive or hysterical in an emergency. If he be shiftless, daring or reckless, it is only a matter of time when, through misjudgment of speed or distance, he will get into trouble.

The Mentally Unfit Are Real Hazards

One of the surest methods of reducing the number of accidents is by making it impossible for individuals who are mentally subnormal to drive automobiles. While education and traffic regulation will reduce a small percentage of accidents, the possibility of reduction by these means is very limited. So long as mental incompetents are permitted to drive automobiles, nothing will prevent them from being the cause of accidents. The situation is the same as if children were allowed to play with loaded guns and sticks of dynamite. They would be sure to get into trouble because "they know no better," as we say. While the dangers from mishandling such objects is minimized by keeping explosives far out of the reach of children, almost anyone over 16 years of age is allowed to play with automobiles, which are as powerful and dangerous as an explosive.

It was discovered during the war that a large number of men were mentally incompetent or subnormal. A great number of such human beings walk the streets, are employed in industries and, perchance, many are even driving commercial vehicles. Because of the possibility that some such defective may apply for a position as a driver, or may be a driver of his own car, it is time that in a civilized community we should protect the public from such hazards. Of course, an individual can be a competent and safe driver without having a superior intellect; all we must be sure of is that the individual who is allowed to operate a powerful vehicle has normal

intelligence, normal emotional stability, cautious habits and fair moral foresight.

Mental Defects That Cause Accidents

It is possible, by the use of psychological tests, to detect with a great degree of certainty both the desirable and the undesirable types of driver. The officers of the Yellow Cab Co., being especially concerned in the safe transportation of its passengers, requested me to devise some method that would eventually reduce the number of accidents to the minimum. To solve this problem I have studied the taxicab driver's job carefully, studied accident records and compared them with the various types of driver. From these studies it was found that a small group of drivers was responsible for most of the accidents; in fact, only 18 per cent of all the drivers were responsible for 46 per cent of all the accidents. Consequently, the problem was to discover what characteristics the 18 per cent of the drivers had in common that made them so liable to accidents. An analysis of this group showed that the men were of low intelligence, were emotionally unstable or were men of careless habits. Therefore, I set to work to devise tests that would enable one to discover in a short time whether or not a given applicant for a job as a taxicab driver was of the type desired, who could and would guide a taxicab safely through the streets of Chicago.

Tests to Determine Driver Fitness

The psychological tests used for that purpose at this time are

(1) *Physical Examination.*—This is made by a physician and consists of a rigorous examination that includes the heart, lungs, eyes, ears, reflexes, blood pressure, the Wasserman test and so on

(2) *Intelligence Tests.*—These consist of a group of very simple problems in printed form. The pamphlet also contains all necessary directions and sample problems so that it can be given to a large group or to an individual without any oral instruction or interpretation except for the taking of the history of each subject. The tests require very little writing and are based on the assumption that the subject has had no formal education and knows nothing except what is taught him while he is taking the tests. He is expected, of course, to be able to follow very simple directions, to make marks and figures and to copy letters.[2] A time limit of 25 min. is set for solution of the problems. We attempt to measure the intelligence of the individual by the use of tests of (*a*) immediate memory, (*b*) attention without distraction, (*c*) attention with distraction, (*d*) span of observation, (*e*) space perception, (*f*) imagery, (*g*) adaptability to unusual situations, (*h*) reason, common-sense type, (*i*) learning, (*j*) speed of reaction and (*k*) perseverance. In our work so far we have discovered that average or superior intelligence is no index of a person's ability or inability to guide a vehicle safely; very low intelligence, however, invariably is an index.

(3) *Emotional Stability.*—The apparatus for this test consists of a small cabinet in which the subject is seated on an ordinary chair in the dark and outside and in front of which is a table supporting two huge electric coils and a big spark-gap behind heavy plate glass. A large sign on the table reads "Danger—25,000 volts." Directly in front of the subject on a sloping board are some wires with loose ends, a number of binding-posts, little electric-light bulbs painted red, an electric contact-key to the left and an electric switch to the right. Directly before the subject's face are two glass tubes with high-voltage wires projecting from them and on the floor are two large brass plates and a pedal to the right of them.

In conducting the test, the subject is instructed in a lugubrious voice to place one foot on each of the plates, hold down the key with his left hand, take the wires in his right hand, insert their ends in the binding-posts and tighten the set-screws as quickly as possible. He is told that if anything unusual happens before all the wires are inserted he must press down with his right foot on the pedal and turn the electric switch with his right hand. Finally, he is instructed not to move prematurely and is then left in Stygian darkness. He is allowed to work uninterruptedly until a number of wires have been inserted, then a switch is moved and a sudden blinding startling discharge takes place through the spark-gap and tubes, electric sparks sputter and crackle from the ends of the wires and the current prickles and stings the backs of his hands.

If the subject can move a muscle during the first few instants of the electrical manifestation, he must have a heart of steel and great presence of mind. The test is designed to show whether a sudden, unexpected emergency renders the subject incapable of moving a hand or foot for a certain period of time or he can, in the face of a terrifying crisis, still compel his muscles to do what he has been told to do. The time is taken by a stop-watch until a telltale light shows that the pedal has been depressed and the switch turned. If the light appears within 1 or 2 sec., the fear-time reaction is good to fair, but if 4 or 5 sec. elapse it is too slow and the subject's emotional stability is poor

(4) *Carelessness.*—The apparatus for this test consists of a small board on which are cut four irregular lanes that begin and terminate in two common points but vary in length and width. The first lane is the shortest but also the narrowest; the fourth is the longest and widest. The lanes contain various obstructions, curves, sharp turns and other irregularities and are lined with metal strips electrically connected with an automobile battery. In series with the board is a stylus that can be moved freely through the lanes but which, when it comes into contact with the side of a lane, closes the circuit and causes a slight disturbance in the body of the subject. Connected in this circuit is an automatic counter that records the number of times the stylus comes into contact with the sides of the lane.

Underneath the board containing the lanes is another board of the same size having a number of contact points so distributed that, when the subject approaches and passes, with the stylus, any of the points of difficulty found in the lane, another electric circuit is completed and results in a movement of an electric tambour that registers upon sensitized paper revolved in a kymograph. On the same paper, by another circuit that operates an electrically maintained tuning-fork, is recorded the time in fractions of a second that the subject takes to complete the test and also to move the stylus through the zones of difficulty.

The subject is told to imagine that the lanes and their obstructions represent street conditions and that it is his task to move his car,

[2] See Psychology in Business Relations, by A. J. Snow, p. 520.

represented by the stylus, through any one of the lanes that he chooses, so that the motion of the stylus which he is to guide will terminate at the other end of the lane. He is also told that the object of the test is to see *how rapidly he can move the stylus through the lane* but that he *must be careful not to touch the sides of the lane*, as this will count against him; that if his stylus comes into contact with any of the obstructions of the lane, this will represent a collision in the street; that the time it takes him to complete the movement will be recorded by a stop-watch, and that the number of collisions he has will be recorded by an automatic counter.

As a matter of fact, the experimenter is interested only in the subject's judgment as revealed by his selection of the lane that he desires to traverse and by the data recorded on the kymograph. This part of the recording apparatus is not visible to the subject nor does he know anything about it. The theory underlying this test is that the careful driver will select the lane that will permit him to make the best time with the least number of "accidents" and that he will slow-down the movement of the stylus considerably as he approaches and passes any of the points of difficulty in his path.

TABLE 1—COMPARATIVE ACCIDENT RECORD OF UNDESIRABLE AND DESIRABLE DRIVERS AS DETERMINED BY THE TESTS

	Unsatisfactory	Satisfactory
Employed after Testing	34	258
Never Started Work	8	10
Dropped Out after Starting	5	50
Working at End of Record Period	21	198
Accidents Due to Carelessness or Gross Negligence	26	50
Responsibility Doubtful	7	19
"No Liability"	9	24
Men That Had Accidents	17	84
Men That Had More Than 2 Accidents	10	32
Average Number of Accidents per Man[1]	1.0	0.2
Men That Had Accidents, per cent[1]	64	33
Men That Had More Than 2 Accidents, per cent[1]	38	12

[1] Does not include accidents in the "Responsibility Doubtful" and "No Liability" columns.

Proofs of the Value of the Tests

The foregoing tests are used at this time for the selection of applicants for taxicab driver positions at the Yellow Cab Co. of Chicago and by other taxicab companies in Louisville, Ky., Cleveland, Pittsburgh, South Bend, Ind., Toledo and Omaha, Neb. In the last-named city the tests are being given by the Omaha Safety Council to any transportation pilot whether of an automobile or a street-car, who wants to avail himself of the opportunity.

Up to date, 8000 drivers of the Yellow Cab Co. in Chicago alone have been tested, of whom 3000 are now in the employ of the company, which employs a total of 6000 drivers. The rejections since Jan. 1, 1925, based upon the applicants' inability to pass the psychological tests satisfactorily, have been 21 per cent of all the applicants. The reduction of accidents since that date has been substantial, as Fig. 1 will disclose. Three independent sources were used to arrive at the percentage of accident reduction resulting from the use of the psychological tests.

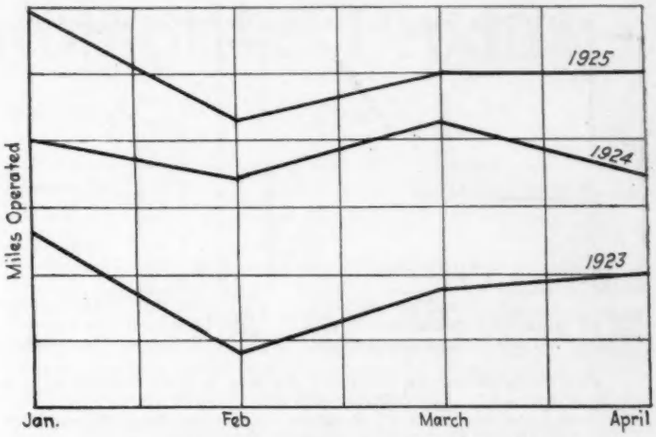

Fig. 1—Comparative Taxicab Miles in Chicago

This Shows the Increase in Business, or Miles of Cab Operation, by the Yellow Cab Co. of Chicago in the First 4-Months' Periods of 1923, 1924 and 1925. A Comparison of This Chart with Fig. 2 Shows That, Although the Cab Mileage Showed a Large Increase, a Proportionally Much Greater Decrease in the Number of Accidents, Particularly Between 1924 and 1925, Occurred

(1) To prove the value of the tests to the satisfaction of the Yellow Cab Co. of Chicago, 311 applicants were tested and prediction made, in a report to the officers, as to which of these new employes would have the larger number of accidents. Only the intelligence and emotional-stability tests were used at that time. The legal department of the company then kept a record of accidents for each driver in the experimental group for a period of 10 weeks. The results of the experiment are given in Table 1

(2) A card is filed for each applicant who has gone through the psychological department and accidents are recorded from day to day on these cards. For various business reasons and also to obtain a further check upon the work, a number of applicants were hired even though they were not successful in passing the tests. A study was made to determine the number of accidents that the "undesirable" employe had as compared with the "desirable" employe, and the results showed that accidents could have been eliminated to the extent of about 35 per cent in that group if only men of the "desirable" type had been employed. In this study

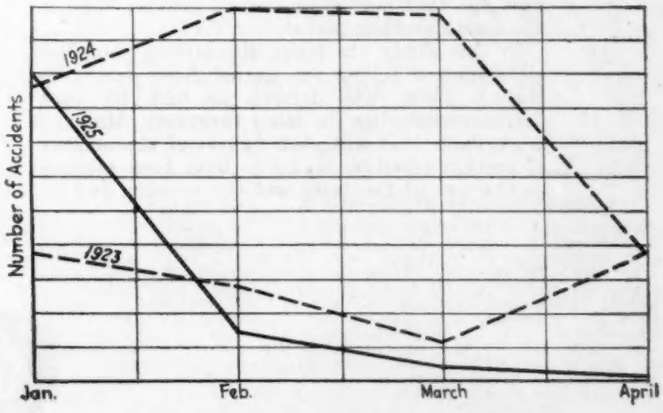

Fig. 2—Taxicab Accident Rate During First 4 Months of Three Years

The Rapid and Continuous Drop in 1925, Compared with the Number of Accidents in 1923 and 1924, Began Immediately Following the Application of the Psychological Tests to All Applicants for Taxicab Driver Jobs Beginning Jan. 1. Only New Employes Are Tested. During January Only 400 Out of 5000 Employes Had Been Selected by the Test Method but by the End of April About Half of the 6000 Drivers Employed Were Tested Men

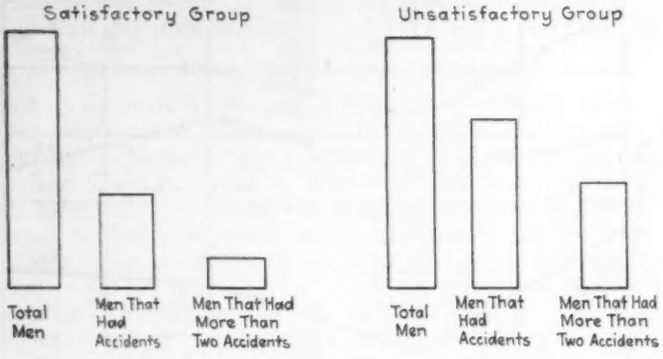

FIG. 3—COMPARATIVE ACCIDENT RECORDS OF TWO GROUPS OF TESTED DRIVERS

The Diagrams at the Left Relate to a Group That Passed the Tests and Were Pronounced Satisfactory; Those at the Right Relate to a Group That Failed To Pass and Were Declared Undesirable as Cab Drivers. The Left-Hand Column for Each Group Represents 100 Per Cent of the Men in the Group. See Table 1 for Percentage Figures

about 3000 drivers were considered for a period of 4 months

(3) The third study, the results of which are shown in Figs. 1 and 2, was made by the legal department of the company. The data used in this study consisted of the records of accidents from month to month beginning with Jan. 1 and ending with April 30 for the years 1923, 1924 and 1925. Also, a study was made of the taxicab miles traversed during the same period. If one considers the distribution of accidents in terms of business, or taxicab miles, it can be seen that a reduction of accidents between Jan. 1 and May 1, 1925, has been effected. When it is understood, further, that the company uses the tests only in the selection of *new* employes and that only 400 out of 5000 drivers in the company's service during January, 1925, were men that were selected by the use of the psychological tests and that this number increases from month to month, so that on May 1, 1925, about 3000 such drivers were in the company's service, then one can imagine the possibility of the reduction of accidents if all of the drivers had been as carefully selected. If the number of accidents during January, 1925, is disregarded, the accident rate for the remaining 3 months was far less than that of 1923, even though the business for that period was much greater than in the corresponding period in 1923

In this study the legal department combined all employes during the period from Jan. 1 to May 1, about 8000 drivers, all told, for each period, considering the labor turnover. Material is available that will yield figures of the number of accidents had by men who have been selected by the use of the tests and the number had by the men who were not so selected. Such a statistical study is now in progress.

LABOR TURNOVER ALSO IS REDUCED

What has all of this meant for the taxicab industry? First, the accident record of the Yellow Cab Co. has been reduced tremendously and progressively from month to month since January, 1925. Second, it has reduced the labor turnover, because drivers who were responsible for accidents were constantly being discharged. Third, because since the tests are given to applicants whether they know how to drive an automobile or not, the undesired applicant can be weeded out before he is sent to the company's school for training. All of which means, of course, that by the use of the psychological tests the company is able to create greater public goodwill and at the same time to save considerable effort and money.

These psychological tests are interesting and harmless. Practically all of the subjects who have taken them, now numbering more than 10,000, claim that they have actually enjoyed taking them. They are easily administered and can be given to hundreds of individuals in a day.

All of us are more or less afraid of finding that something is wrong with us, whether physically or mentally, but it is better to know that a certain disease, such as cancer, has just begun its destructive inroads than to discover the fact when it is too late. Just as timely discovery of cancer may save the individual from considerable pain or death, so, in the discovery of a mental defect, the individual, by knowing of it, may refrain from driving a powerful automobile and in that way prevent injury to himself and to others.

SELECTIVE METHOD MUST BECOME UNIVERSAL

It will be only by the process of elimination or selection of drivers that we will be able successfully to control the automobile accident hazard. Such a process already is in operation in some of the Eastern States, notably in Massachusetts, where the legislature passed a motor vehicle law that permits the license bureau to refuse an operator's license to any person who is found to be mentally defective. This new law has been in operation only about a year, but the reduction of accidents during this year has been very great. Similar measures are sure to be introduced all over the world in time, because the individuals who are potentially likely to have accidents must be prevented from driving cars before any marked reduction in the number of accidents can be effected. By the proper selection of operators, by education of the pedestrian and by strict enforcement of traffic regulations the increasing highway accident rate should be cut down until it will become negligible.

Distribution of Automotive Products

By RAY W. SHERMAN[1]

METROPOLITAN SECTION PAPER *Illustrated with* CHART

ABSTRACT

AUTOMOTIVE products, like other manufactured goods, must pass through a distribution system to the consumer. This system is pictured as a pyramid divided into five sections, with the raw materials and parts at the apex, with the manufacturers of the finished products, the wholesalers and the retailers following in the order named and the consuming public at the base. Everyone engaged in the industry fits into this picture somewhere; the engineer belongs with the manufacturer; a manufacturer's agent functions as a sales department of a factory and belongs in the same group; a specialty jobber handling several lines occupies a corner of the wholesalers' section. Sometimes a manufacturer sells direct to retailers and occasionally tries to sell direct to consumers. In such case he functions throughout the distribution system and must perform all of the functions.

The effort is always being made to force products through the system from the apex to the base, and this costs money. The retail price of an article is generally about five times the manufacturing cost. Exceptions will be found, but the rule generally holds good. If the cost of marketing an article is too great, someone else will find a way to do it more cheaply and outsell the original producer.

When merchandise fails to pass through the system, it backs up, and a condition of overproduction accompanied by business failures occurs. An article will not get through if the fundamental laws of business are violated. Unless the engineer designs and the manufacturer produces something the public wants, the consumer will not buy it, and if the wholesaler or the retailer do not function to the satisfaction of the public, the consumer will decree that he shall pass out of the picture.

From the beginning the industry has been prone to ignore the laws of supply and demand, assuming that the only factor necessary to consider was supply. If an automobile saturation point ever existed, it was passed some time ago. The public has decreed all that has happened in the past and will decree to an even greater extent all that occurs henceforth.

The automobile business was slow to start, compared with the radio industry, because the radio was the toy of all classes. This illustrates the effect of price.

A fatal mistake often made by engineers and manufacturers is in trying to force on the public through the distribution system something that is not wanted. Considerable time and money would be saved if inventors, engineers and manufacturers would first find out what is wanted and then supply it. That would render a service to the public and to a great industry and result in success.

EVERY engineer in the automotive industry should be interested in distribution because, without distribution there will be no engineers. The total volume of business done by the people in this Country amounts to about $50,000,000,000 a year, of which the automotive industry does about 10 per cent. The American people spend for automotive products about $5,000,000,000 a year.

When the structure of the automotive industry is considered, it takes a form something like Fig. 1. Almost everyone concerned with automotive distribution can be fitted into a picture of this character. At the top are the raw materials and the parts of which certain of our products are made. Parts are related to raw materials in a way. In the next section of the pyramid are the manufacturers and the engineers. In the middle section are the wholesalers, representing jobbing distribution. In the next division are the retailers, who are in contact with the public. At the bottom are the consumers or public.

This business, or any other of similar character, is built upon just about that basis. If you walk down automobile row and look at the automobile signs, the salesrooms, the tire stores and the rest, it seems like a hodgepodge of an industry, yet everything you find will fit into this picture. For example, the wholesaler

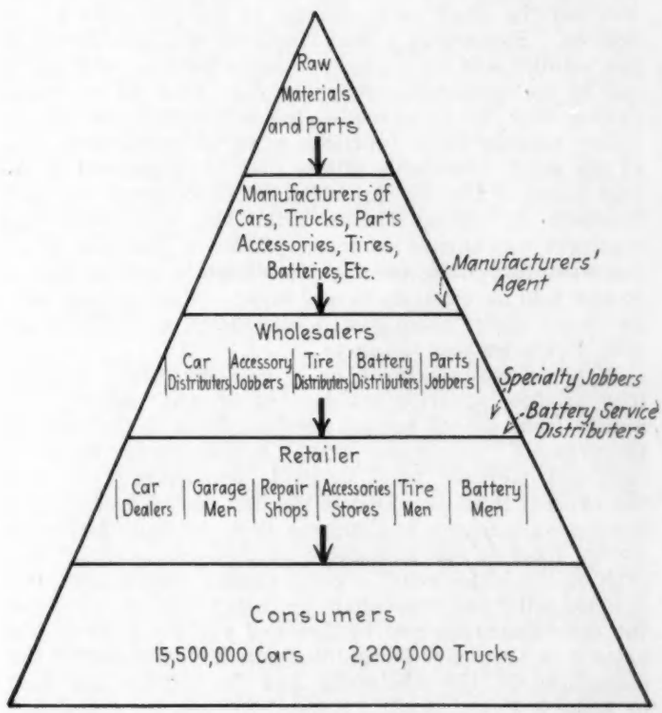

FIG. 1—PYRAMID OF THE AUTOMOTIVE DISTRIBUTION SYSTEM

Starting at the Apex, Raw Materials and Parts Go to Manufacturers Who Produce the Finished Products. These Are Sold to the Wholesalers, Who in Turn Supply the Retailers, Who Sell to the Consumers at the Base. Everyone in the Industry Fits into This Chart Somewhere. When a Manufacturer Sells Direct to Retailers, He Merely Assumes the Function of the Wholesaler, and if He Sells Direct to Consumers, He Assumes the Functions of Both Wholesaler and Retailer. If a Product Does Not Meet the Desires of the Consumers or If the Distributing Cost Is Too High, the Product Backs Up and the Manufacturer Is Eliminated, and, If Many Products Back Up, a Period of Overproduction Ensues. A Wholesaler or Retailer Who Does Not Function to the Satisfaction of the Consumer Is Forced Out of the System

[1] Editor *Motor*, New York City.

class takes in the distributer of automobiles, who takes the product from the shipping platform of the factory. He passes it on to a dealer and the dealer passes it on to the consumer. Accessories come down from the manufacturer through the wholesaler to the dealer, who sells them to the public. It is the same with tires, batteries, parts and everything else. The retailer class includes the car dealer, garage man, accessory store, battery man, electrical stations and tire stores and others that serve the public directly. In the consumer class there are today 15,500,000 persons owning the passenger cars the manufacturers have built and the owners of 2,200,000 commercial vehicles, a total of 17,700,000 vehicles running on the roads in this Country.

Occasionally you will find a manufacturers' agent; he functions as a sales department for the factory, selling generally to the wholesaler, and belongs in the manufacturers' group. Then you will find a specialty jobber who handles only a limited number of lines; his place is somewhere in one corner of the wholesalers' division.

All Functions Must Be Performed

Starting at the top with raw materials or parts, the manufacture of the product begins. That is where the engineer comes in, but unless what is made can be sold, the engineer has no place. The effort is always to bring merchandise down from the top to the consumer at the bottom. Sometimes a manufacturer will sell direct to the retailer and occasionally a manufacturer will try to sell to the consumer. When he does that, he is simply taking over the functions of the wholesaler and the retailer, because these functions must be performed. One of the most regrettable things that has happened in recent years is the dissemination of misinformation, particularly in official circles after the war when the spotlight was turned on many phases of business alleging wastefulness in merchandise distribution. It applies to our field as much as to any other. Much of our very necessary distribution cost is considered waste by those who do not possess the facts.

A parts manufacturer or a raw materials supplier may produce superior articles but of what avail is his ability if he cannot put his product down to the base of the pyramid? He cannot exist. It costs money to do it; rent and overhead must be paid, men must travel and the expense must be added to the cost of the product. If anyone were to say in Congress that the manufacturing cost of most of our manufactured products is about one-fifth of the retail price, a great clamor would arise, but it is the truth and you cannot get away from it. Multiply the manufacturing cost by five and you get close to the price it is necessary to receive from the consumer if the manufacturer, the wholesaler and the retailer are each to make a living profit. Exceptions will be found but that statement comes very near to holding good in general.

Merchandise, which is the product of man's vision, inventive genius and desire to make money for what money will do, is always trying to push its way down through this distribution system to the consuming public. If it fails to get through, it begins to back up, resulting in a period of overproduction and the business disasters that accompany such a condition. During the quarter century the automobile industry has been in existence, considerable blackballing of merchandise has taken place in the Consumer Club and it has cost the industry a tremendous amount of money.

[1] M.S.A.E.—President, General Motors Corporation, New York City.

Cannot Ignore Fundamental Business Laws

That, briefly, is the story of automotive distribution. A product must come down from the apex to the base of the pyramid at the least possible cost because, if it is done too expensively, someone else will find a way to do it cheaper and he will outsell the product in the market. One point that seems important to consider is that ever since this business began we have not had a proper conception of it. A. P. Sloan, Jr.[1] stated recently that

> Any man who has attained the age of 25 or 26 years has just about outgrown his boyhood days, and if he is ever going to be a man, he is a man at that time.

This industry has now reached that age.

In the years we have been struggling along building up the industry, with only an occasional slip back, we have labored under many expensive delusions. One is that we have been prone to believe we were not subject to the fundamental laws of all business; we disregarded the law of supply and demand. Because the world had been waiting for thousands of years for an improved means of individual transportation and because the production of such means in quantity suddenly became possible, we believed that supply was the only essential and that demand would take care of itself. The truth is that the automobile business is just like the drug, cigar and every other business, and that the laws that govern all other business also govern this.

Consumer Decrees Success or Failure

The consuming public is the factor that engineers, salesmen, dealers and all of us must study intensively if we are to achieve the largest success. The consumer has put out of business in 25 years more than 500 automobile manufacturers because they disregarded some of the fundamental laws in attempting to force their products through the distribution system and did not secure the consumer acceptance that was needed. A year ago, 66 makes of automobile were exhibited in the New York Show; this year 52 were exhibited in the New York and Chicago Shows. How many will be shown next year no one knows but I think it is almost safe to predict the number will be under 52. Why has this occurred? Because the consumer decreed it. He has decreed everything that has happened to date in this business and will decree to an even greater extent everything that happens from now on, because, if any saturation point ever existed, it was passed some time ago.

The situation regarding the parts jobber is interesting. It was not the manufacturer seeking a market who created the parts jobber, it was a demand by the consumer, and if the parts jobber functions to the satisfaction of the consumer group, he will continue to be a factor in the field; otherwise he will pass out.

Hundreds of manufacturers of accessories have been forced out of the picture by the group at the bottom of the distribution pyramid because they did not perform in the way this group thought they should. A large proportion of dealer turnover has been due to other causes but much of it was decreed by the group at the bottom, because the dealer and the garage man did not function to the satisfaction of the consumer. Years ago, in an address before the Michigan Automotive Garage Association, I tried to get over to the garage men the thought that their places of business did not look very attractive. I said, "When you go back home, look at your place and see how it would impress you if you were about to go in to spend your money there." The next time they had a

convention, one of the men stood up and said that was the greatest idea he had ever heard; that when he went home he looked at his garage and then put in window lights and cleaned out the cobwebs. Three years later he went out of business. He was all right so far as the window lights and cobwebs were concerned but in other things he was all wrong.

Consumer Acceptance a Vital Necessity

The radio business has had its effect on the automobile industry. It started as a mysterious whispering and almost over night grew into an industry that today runs into millions of dollars. Why? The automobile required 12 or 15 years to get started because the automobile was "the rich man's toy," and the great consumer class could not afford to play with it. When radio came into the field, the toy of all classes, the people said, "We want this thing; we will have it." Moreover, radio challenged the inventive genius of millions of boys from 8 to 80 years of age, and no other result could have happened.

Some car manufacturers came into the automobile field, attained to a certain success and then suddenly passed out. They all violated some rule. I recall, with all respect to some good friends, arguing with a Mitchell man one day about the tilted radiator, which was one of the last mistakes the Mitchell Company made, and it made a number. That man spent 15 min. trying to convince me it was a clever idea. "All you say may be true," I said, "but I would never buy a car that looked like that." A Mitchell territorial salesman had a dealer in California all ready to sign a contract for their automobiles when a boy came along and said, "Say, mister, how did you bump your radiator?" That dealer did not sign the contract and Mitchell cars were not represented in that territory. The public did not want the tilted radiator and the plant was sold at auction recently. That same principle applies to many other products in this business. It is not what you want to make; what you, as an engineer, think a product should be will not make it a success. It must be the kind of product for which the consumer will pay his money. If you can make it the way he wants it, you will be a successful engineer, but if you spend your life making it the way you think it should be built and the public is not in agreement with you, you have not a chance in American industry.

A few days ago I was looking through the *Patent Office Gazette* and noticed that every once in awhile somebody invents something which, to make the car safer, takes the control of the automobile out of the hands of the driver, such as a bumper that, after you hit a man, knock him down and kill him, turns off the ignition and applies the brakes. Anything that takes the control of a motor car away from the driver is unsound; the public does not want it. Inventors have spent years on products of that kind. If they would go out first and find that the public does not want it, they would save themselves considerable time and money. But if you can find something that is wanted and make it, you are rendering a service to a great industry.

THE DISCUSSION

H. G. McComb:—To what extent are sales-surveys being made by companies in the motor-car field? The General Motors Corporation has, for a long time, been making a very definite attempt to find out what "the man in the street" thinks of the organization and its products, and we have seen the progress of that company, but some of the companies appear to be far from either knowing or caring what the public thinks of their products. Do you know the percentage of existing companies that are making careful sales-surveys?

Mr. Sherman:—The General Motors Corporation has just completed what is without question one of the greatest sales-surveys that ever has been made. It has spent a tremendous amount of money on it and has on a sheet of paper the probable yearly automobile sales in this Country to far beyond 1930. It thinks it has hit within a few automobiles of what will be the market for a long time to come and the company is basing its production on that survey. I do not think anyone has ever even approached a job like that; so far as I know, it is the only real undertaking of its kind. Some companies investigate to a considerable extent but I do not know what the percentage is. Many of the smaller ones that make a few hundred automobiles annually do not need any sales-survey; all they have to do is to make a small number and sell them at a limited total profit, regardless of how big the market is.

N. G. Shidle[3]:—One difficulty, particularly in the last 2 or 3 years, has been, not so much that the companies have not attempted to make surveys, but that when they did so they did not want to believe the results. If the survey did not come out the way the sales manager wanted or in accordance with the capacity of the plant, they said, "Well, we cannot do anything about that; we have the capacity to build so many cars and that is what the market is." Some real efforts have been made by a number of companies but the investigators have not had the confidence of the men who had authority to act on the results. I do not think any definite or wide surveys have been made to learn the opinion of the man in the street about the product.

All Middlemen Are Wholesalers

A Member:—Do you think it is sound business or in the scheme of things to have more than five channels through which the products must go? For instance, is there room for somebody between the wholesaler or jobber and the retail dealer to get a profit, or is it economically sound that only four groups should get the profits? If there are more, the profits naturally must be more, and will that make the cost to the consumer prohibitive?

Second, what is the effect of advertising in convincing the public that it likes something? In the case of the Mitchell, would it have been sound economics to have attempted to convince the public by proper advertising that it liked a tilted radiator?

Mr. Sherman:—Several questions are tied up in that ball. The distribution of automotive products and almost everything else varies according to conditions. In each community it is necessary to have retail outlets and, if these reach a considerable number, the manufacturer cannot well handle the retail business himself because credits and other things make it too difficult. A middle step must be provided; you asked if it were possible to put in additional steps.

A Member:—Yes, between the wholesaler and the retailer; for example, the Champion Spark Plug Co. has wholesaling jobbers and it also has made provision for a sub-distributer who buys from the wholesaler and sells to the car dealer or the garage man and the accessory dealer. It is a forced distribution.

Mr. Sherman:—The example cited is not exactly the case you have in mind. In the Champion and A. C. sys-

[3] A.S.A.E.—Managing editor, *Automotive Industries*, New York City.

tems of distribution an attempt is being made to develop exclusive distribution on each line of plugs, getting a certain number of accounts to concentrate on the Champion and others on the A. C. plugs. To do that, a special arrangement has been made with certain jobbers but they are not really middlemen between the factory and the jobber. The additional discount they receive is not very large; they carry a little more stock, perhaps, but they really are jobbers on the same level with the other jobbers except that they have a little better arrangement, as I understand the system.

If you are a manufacturer starting in business, have a product that is good and there seems every reason why you should be able to sell it to the consumer but the sales volume is not likely to be large enough, during the early years at least, to enable you to maintain a sufficient organization to travel all over the United States and Canada to sell to the necessary number of jobbers, you must cut down your merchandising cost, so you put in a manufacturer's agent as an additional step in distribution and thereby decrease the distribution cost, because the manufacturers' agent handles six or eight different lines and sells to the wholesaler. Again, in Cortland or Oswego, N. Y., for example, where the territory is not large enough to justify a real jobbing business, a man may be doing a retail and jobbing business because he can serve the needs of some of the small retailers in and around the city who mostly come in and buy over the counter. He is a sub-jobber or semi-jobber. In real jobbing circles they say there is no such thing, but there is and it does not increase the cost of distribution, it is not an additional class; the man fits himself into one of the classes in the pyramid and functions along lines that are needed.

Advertising Unwanted Product Causes Loss

As regards advertising, the first thing to do is to ascertain that you have a salable product; if you have, then advertising can create a market and sales, but if it is not salable more money will be spent trying to sell it than will ever come back and there will not be any repeat business.

G. A. Sheller:—Is it not true that most of the manufacturers of taxicabs reach their consumers direct and have eliminated the wholesaler and retailer?

Mr. Sherman:—I imagine they do, and in the case of tools and equipment the manufacturer reaches his consumer with one jump because the dealer and the garage man are the consumers and the manufacturer sells to them with only one middleman.

Mr. Sheller:—The ones I have in mind sell direct to the public without any retailer.

Mr. Sherman:—I see no reason why it should not be done, because the market for taxicabs is comparatively limited.

W. E. Kemp[4]:—Have you made any study of what is known generally as the specialized distributer or jobber, the man who handles five or six lines that are very special and that require a certain amount of service, rendering it almost impossible for them to be handled through the ordinary wholesale channel? Have you any figures to show the growth of that particular kind of business?

Mr. Sherman:—It has grown and become very large.

Giving Too Much Value

Mr. McComb:—From figures published in the papers it appears that the purchasing power of the dollar, in most of the commodities we use, is only 65 cents today compared with the pre-war dollar. The automobile manufacturers tell us, with a good deal of pride, that they are giving the public $1.15 worth of value for its dollar. How can any group of manufacturers, no matter how clever, continue to give $1.15 worth of goods when manufacturers in other lines are able to give only 65 cents' worth? What will be the trend in that respect? What sort of future does the business hold for us who have devoted most of our lives to it?

Mr. Sherman:—Whenever I say that automobile prices will go down, they usually go up, so it is dangerous to make any prediction, but I think the automobile value today is too great and too much money has been lost in the business. The man at the base of the pyramid has received the benefit and sometimes the manufacturer at the top has secured some benefit, but not enough profit has been made down through the distribution chain. Parts manufacturers have sold parts to car builders at prices that did not leave the parts makers any profit. It is not sound economically and should not be done; the custom is beginning to decrease and it will decrease more. Parts are likely to cost more in the future than in the past.

Then the dealer has been operating on a discount of about 20 per cent. The additional 5 or 10 per cent that he should have had has been passed on to the consumer, who gets nearly twice as much value in an automobile for his dollar as he can get in other goods. One car manufacturer is now considering bringing out an automobile and giving his dealers 30 per cent and his distributers 40 per cent. I think you will see a return swing in discounts and somewhat higher prices in many cases.

R. E. Plimpton:—What do you think is the future of the manufacturer who sells parts or accessories in the replacement field? Will the type that handles 20 or 30 specialties and has traveling men throughout the Country increase? They may succeed with certain products whereas a more complicated product can be handled in a more satisfactory way if a company sticks to one line.

Mr. Sherman:—That depends largely upon the man; one man sometimes can be very versatile in the number of lines he handles but the ordinary man cannot go beyond a certain limit. What it is I do not know; it is up to him to find out because he has to depend for the success of his enterprise on other human beings, whom he hires, to go out and represent him and they are even more limited in versatility than he is. I do not think we shall see any large number of products handled by single companies. Much talk of mergers in parts like pistons, pins, rings and other engine parts has been heard. Often, when they are all corralled, the retail trade decides it would just as soon buy somewhere else and the mergers do not get so far as they think they are going.

Production Needed for National Distribution

R. E. Fielder:—Suppose a manufacturer is producing automobiles and wants distributers in every State and principal city; what should be his factory production, either in number of automobiles or in millions of dollars?

Mr. Sherman:—That raises the question, What is national distribution? Henry Ford has about 9700 direct dealers and 28,000 licensed service-stations. That is real national distribution. Some other companies that advertise and sell nationally really do not have national distribution. When Dodge Bros. started they had a

[4] A.S.A.E.—Eastern distributor, Byrne, Kingston & Co., New York City.

plant and knew they could build a certain number of cars the first year and they were able to secure the confidence of dealers. They contracted with a certain number of dealers to supply each with enough automobiles for him to make money on but not too many for his market; in most cases the number was just a little too few. They took on enough dealers to absorb the factory capacity and no more. They always have operated on that basis and have made one of the most phenomenal successes in the industry.

MR. KEMP:—Is not the small independent truck manufacturer who supplies a territory adjacent to his plant increasing in number as well as in volume of business as compared with four or five years ago?

MR. SHERMAN:—Localizing of the truck business seems to be a trend that has worked out successfully with a number of companies. They operate intensively within a few hundred miles of their factories and a truck company in New England does not try to sell in San Francisco because a company can start in San Francisco and buy parts and materials and build trucks to sell locally at much lower cost.

MR. SHELLER:—Was it because competition was so keen that the discounts to the wholesaler and dealer have been small?

MR. SHERMAN:—The answer is more or less obvious. One potent factor has been the manufacturer's ability absolutely to dominate the situation, because until recently the market was always crying for cars and men were always trying to become dealers. I think the pendulum will swing over to where the dealer will be the dominating, and the domineering, factor before it arrives at a static condition. Before long, dealers will be dictating to manufacturers. One evidence of this is that many dealers have liquidated within a year or a year and a half; withdrew their money and quit the business.

MUST DETERMINE WHAT THE PUBLIC WANTS

E. B. STURGES[5]:—What is your idea in regard to what the public wants? You stated that the tilted radiator interfered with the sale of the Mitchell car. Competition is so keen that, as a rule, each company tries to produce something a little better than the others to increase its sales. How could the engineer tell in advance whether or not that tilted radiator would take with the public?

MR. SHERMAN:—If an organization does not have a marketing sense and cannot acquire it, it is hopelessly sunk. Then, the manufacturer has a dealer organization and all sorts of avenues through which he can get information, so it should be possible to find out a thing of that kind without great difficulty.

TREND TOWARD RECONDITIONING CARS

A MEMBER:—A movement is afoot to combat the high sales pressure of car manufacturers and dealers by inducing owners to have their cars repaired, overhauled and rebuilt instead of buying new ones. Several local organizations have started an advertising campaign with that object. Do you think that can possibly make any headway against the tremendous resources of the car manufacturers?

MR. SHERMAN:—It did last spring and many cars piled up in warehouses. The sudden acquirement of common sense by the consumer was one of the big factors that caused overproduction. Nothing can stop that trend because it is common sense.

A MEMBER:—What do you think of the economic soundness of maintaining a high list price and allowing dealers either a percentage or a flat sum of money to help them take trade-ins?

MR. SHERMAN:—Large production cannot be achieved on that basis because somebody else will beat the price, but if the automobile verges on the custom job that is expected to reach only a limited market and the dealer is compensated by that discount for the extra effort he has to make to sell it, a successful business can be done.

LARGE COMPANIES DROPPING DISTRIBUTER SYSTEM

MR. KEMP:—Have you any figures on the number of manufacturers who are handling their cars through wholesale distributers rather than directly through their dealers?

MR. SHERMAN:—At one time almost every company did that but as a company gets into large production the tendency is to sell direct to dealers. Companies that are not already on a dealer basis doubtless will come to it eventually. Many of the individuals who have been operating distributing companies are getting well on in years and, as they pass on, I think you will see a rapid shrinkage in the distributer system.

A MEMBER:—Do you feel that the free-service clause of the dealer's contract is warranted and, if it is, do you not think the factory should make a flat price allowance, aside from the normal sales profit, to cover the free service the dealer has to render?

MR. SHERMAN:—Most of the guarantees that go with an automobile are not a guarantee but a limitation of the manufacturer's liability. When a part goes wrong, I certainly think the factory should compensate the dealer for the expense to which he has to go in replacing it.

O. P. SELLS[6]:—Last evening, at a meeting of the American Society of Mechanical Engineers, I listened to some remarks on the subject of the Engineer in Business, which is really what Mr. Sherman has touched upon. When a product goes from the manufacturer's engineer to the public, the engineer is really getting in business. The product must be acceptable to the public before the engineer can make a real success, as was outlined clearly by Mr. Vauclain, president of the Baldwin Locomotive Works, who has marketed more than 80 per cent of his company's product himself as an engineer because he met the demand of the public for lower freight rates by reducing the cost of locomotive haulage per ton-mile. Another speaker was Chairman Kruttschnitt, of the Southern Pacific Railway Co., who gave some facts concerning the company's maintenance and operating engineers. On one line the operating engineers have made a reduction of a few cents per ton in haulage because they understand that the business of the road is to meet the demand of the public. So in our business, the automobile that best meets the needs of the consumer for the least money in first cost and in maintenance should win, the public's approval thereby reflecting credit to the engineer and indicating to him that *he is* an engineer in business.

[5] M.S.A.E.—Secretary-treasurer, Weiss Engineering Corporation, New York City.

[6] M.S.A.E.—District sales manager, Double Seal Ring Co., New York City.

Best Location for Carbureter Intake

By A. H. HOFFMAN[1]

LOS ANGELES GROUP PAPER

THE discussion of Professor Hoffman's paper was entirely oral at the time of the meeting and the stenographic report has been submitted for correction to those who took part. An abstract of the paper, as published in THE JOURNAL for May, 1925, is printed below so that the reader of the discussion may have an understanding of references made by the speakers to statements contained in the paper.

ABSTRACT

TESTS to determine the location under the hood of a motor vehicle where the air-intake of the carbureter will be exposed to the least dust were made by the agricultural engineering division of the University of California at Davis, Cal., and the results are given in the hope that they will serve a useful purpose. Of three types of dust-screen devised to catch the dust at different locations so that it could be photographed, yet which would present little hindrance to passage of the air from point to point under the hood, the most effective was one of coarse hospital gauze stretched over frames set in transverse vertical positions on either side of and above the engine.

The tests were made on two phaetons and a speed truck, run for less than 3 miles and following another car on a dusty road. Photographs show the screens in position in the vehicles and removed to show the distribution of dust as collected under various operating conditions, as with the radiator fan idle and with it revolving with the fan-belt normally tight.

The conclusion reached as a result of the tests is that, in normal cases, the best carbureter-intake position would seem to be (*a*) on the side of the engine on which the fan-blades have a descending motion, (*b*) about midway between the radiator and the dash, (*c*) about midway between the side of the hood and the center line of the engine, and (*d*) about one-third of the distance down from the top of the hood toward the top of the cylinder-head.

THE DISCUSSION

A MEMBER:—We can hardly overestimate the value of the work of Professor Hoffman. He has taken hold of the air-cleaner problem as probably no other man has done before in the United States and has systematized his methods of tests in such a way that now his methods are considered practically standard throughout the Country.

The question of air-cleaners is just beginning to receive the necessary attention it deserves. Heretofore the automobile engineer has devoted his attention to the designing and production of cars, without giving much attention to performance after they have had the demonstration tests. I know of one engineer who is designing a very high-class motor-coach engine and who has as his objective a powerplant that will operate 100,000 miles without an overhaul. One of the first things he took up was the installation of air, oil and gasoline cleaning devices.

The General Motors Corporation has appointed a board of 20 engineers to investigate air-cleaner methods and types of devices and to make recommendations to its factory heads on types of air-cleaner for all of the General Motors cars and trucks. Mack Trucks has also made an exhaustive investigation of this subject and many other companies are considering air-cleaners.

The most difficult problem we have to solve is that of education. The opportunity to sell air-cleaners, if we can convince the user of their real value, exists. Professor Hoffman gave his paper[2] on the final results of his 1924 series of tests at the last Annual Meeting of the Society and the principal discussion at that meeting was on air-cleaners and crankcase-oil dilution. Available data on the actual performance of air-cleaners in service are lacking to a great extent; the data are hard to secure and they vary considerably with different operations and methods of operation and also with the men who are conducting the tests. An attempt was made last summer to obtain some valuable data on air-cleaners fitted to a number of trucks operated by the California State Highway Commission but, unfortunately, when the trucks were put into operation, the main objective was to hurry through with the jobs, and the control of the apparatus and the drivers was not invested entirely in those who were making the tests. As a consequence, much useful information was lost; cleaners were removed and not put back properly, and, when the results of the tests were analyzed, it was surprising how few reliable data were secured.

The Quartermaster's Corps made one test several years ago on two Liberty 4¾ x 6-in. engines, one with and the other without an air-cleaner. I do not have available the exact mileage of that test but it was conducted along the Mexican border and the engine without an air-cleaner was completely worn out after approximately 3000 miles, while the one with the cleaner showed so little wear that it could be continued in operation with very little overhauling.

The objectives are to (*a*) remove, as nearly as possible, all dirt from the air; (*b*) do it with the least possible restriction of air-flow and the least possible increase in fuel consumption and (*c*) have as little mechanical trouble as possible with the cleaner. The third objective is difficult of attainment with most air-cleaner constructions if high efficiency and low vacuum are maintained.

One designer of air-cleaners states that he set out to design a filter to fulfill the three objectives mentioned. He had the benefit of experience with the first types of centrifugal oil-cleaners and of the dry-cleaners having a felt-covered wire cylinder which had been on the market for a number of years, and realized that if he was to succeed in putting on the market a filter that would not choke he would need to have a filter sufficiently large to pass air freely and still not take too much space. He recalled that precipitation in fluids varies as the sixth power of velocity and believed that certainly in air travel the precipitation would be to the sixth root. I was skeptical of the results to be obtained with a centrifugal dry cleaner but, after going over the tests, I was surprised to find an efficiency of 99.8 per cent and that the cleaner would not choke; it actually worked in practice, and, on slowing down the air current, it really did precipitate the dirt out of the cleaner. It did not depend entirely on the velocity; the direction

[1] Agricultural engineering division, University of California, Davis, Cal.

[2] See THE JOURNAL, March, 1925, p. 367.

of the air current was altered by lugs and it was also necessary to pass the air through a felt filter. The felt used had to be strong enough to withstand hard usage and had to be of a kind through which air would pass freely without restriction but which would take out the dust. The search for the felt cloth took more than a year. Now the cleaner has high-test dust extraction with freedom of air passage and a very low vacuum. I have yet to see any car burning more gasoline with the cleaner on than it used before. We never have changed a carbureter on account of installation of the cleaner, although in some instances we have had to redesign the fittings so they would work better. We make the cleaner in larger units for tractors and shovels and have established a service department and are watching installations carefully.

R. K. HAVIGHORST[3]:—I wish to emphasize Professor Hoffman's remarks about giving air-cleaners a chance by placing the intake where it will get the cleanest air possible. At the Denver tractor exhibition in 1919 the tractor representatives always removed the air-cleaners, evidently being willing to ruin the engines for the sake of giving a satisfactory 2 to 4-hr. demonstration. In one case, after a run of 3 hr., the top piston-ring was missing, the middle one looked like a safety razor blade and the third ring was very thin, though still measurable. I examined some other engines and found the experience almost identical. That drew my attention to the necessity of having efficient air-cleaners. Experiments were carried along in an unsatisfactory way until the Samson Company finally developed a cleaner of its own. During the summer of 1922 I had the privilege of viewing Professor Hoffman's experiments and obtained some ideas that were applied later. The air should be taken from a point where the dust is the least, if possible. In a passenger car it can be taken from under the seat. If the air is taken from a point where it is cleanest and if a cleaner of high efficiency is used and is connected so that no leaks of dusty air occur, and if the lubricating oil is kept clean, the average well-designed engine will wear slowly.

EUGENE POWER[4]:—We are trying two or three makes of air-cleaner but they have not been on the trucks long enough to indicate beneficial results positively. We are convinced that they will do all that we expect of them but I have no information based on actual performance. It is essential that care be given them by the operators and that the cleaners be given a chance to do good work. After we had one in use for 2 months, we wrote to our district office to find out what the men there thought of it and the office replied that it never had been opened. Then they began to complain of carbureter trouble. It should be impressed on users that the air-cleaners must be kept clean.

T. O. DUGGAN[5]:—As a result of considerable experience we have found that the human element is a serious problem in the air-cleaner situation. We could not get the operators to clean the air-clarifiers and there was restriction due to carbon. We would like to know what is to be done about the human element in actual operation. If the operator does not take care of the air-cleaner, the efficiency of the engine is reduced, gasoline consumption increases, coke is formed and carbon is deposited in the engine. What we would like to know, when recommending air-cleaner installations, is how the equipment for which money is spent is to do the work expected of it if the operator is negligent and does not look after it. It seems that the problem is how to make the device automatic and foolproof and to induce the user to operate it intelligently.

E. B. MOORE[6]:—Two years ago we were putting-in 800 acres of alfalfa and after the tractor had been in service less than 15 days, following a complete rebuilding, it would not pull. It was equipped with an air-cleaner and we found that it had not been taken care of. We overhauled the engine, put it back on the job and told the foreman to clean the air-cleaner regularly. They finished planting the alfalfa without further engine trouble. If an air-cleaner can be built that will be automatic, it will be the solution of the problem.

W. H. FAIRBANKS[7]:—We have in service two types of air-cleaners but they have not operated long enough to prove much. I have heard almost no complaint of bad effects from fog or atmospheric moisture. However, we are checking-up this condition closely. We operate a long-distance telephone line across the Colorado Desert to Yuma, Ariz., and we have a specially equipped Ford for the use of our trouble men. Dust is plentiful and sand-storms frequent. Among other things, the car is fitted with an air-cleaner. We brought this Ford in for overhaul after about 5 months' service and 5500 miles of travel. The engine was fouled with dirt, grit and sand on the outside, but the pistons, rings and cylinder-walls were in good condition and showed no appreciable wear. We are not worrying about the human element in regard to the use or abuse of air-cleaners. If a man will not obey orders and give his equipment fair usage, we let him go and get someone on the job who will.

MR. POWERS:—I have been told that in certain types of dry air-cleaner an appreciable increase of carbureter trouble due to lean mixture is experienced if they are subjected to heavy fog. Has anyone had experience along that line?

PROFESSOR HOFFMAN.—Reports of certain cleaners choking-up have come to me a number of times and I have tried to trace them down but found the evidence inconclusive. Here are a few questions handed me: (*a*) How often does a cleaner need attention? Answer: That varies tremendously; no definite period can be given; it should be cleaned whenever necessary to maintain efficiency and avoid undue restriction of air. (*b*) What quantity of dust is collected per mile of travel? Answer: A list of six vehicles was given in the March issue of THE JOURNAL with the quantity collected by each. A Dodge car, in 1 year's use, driven 3600 miles, about 50 per cent of which was on paved roads, showed 0.00277 grams of dust per mile. An International Harvester truck, driven over the state of California for 4 months and run over 6000 miles, 87 per cent on paved highways, collected 0.00106 grams per mile. I do not see any reason why, under the average conditions in California, an air-cleaner could not be put on any ordinary automobile or truck and forgotten for considerable periods, given attention only once or twice a year. How often it should be cleaned depends largely upon the nature of the work and the weather conditions and the amount of dust met with. (*c*) How great is the wear of the top piston-ring and the upper portion of the cylinder? Answer: The top ring wears several times as fast as the second and third rings, because the dust gets first chance at it, and the oil at the top ring, being warmer, is much less vis-

[3] United Parcel Service, Los Angeles.

[4] M.S.A.E.—Superintendent of automotive equipment, Union Oil Co. of California, Los Angeles.

[5] A.S.A.E.—Sales manager, Chanslor & Lyon Co., Los Angeles.

[6] M.S.A.E.—Superintendent and manager, L. A. Automotive works, Los Angeles.

[7] Supervisor of shops and vehicles, Southern California Telephone Co., Los Angeles.

cous than it is at the lower rings. In addition, the top ring must stand direct explosion pressures. The film of hot oil can be squeezed out readily and, being thin, allows more particles of dust to rest against and cut the bearing surfaces. (*d*) How much dust gets into the crankcase oil? Answer: Some idea can be obtained by referring to the February, 1925, issue of THE JOURNAL, pp. 232 and 249. Carelessness in permitting the use of dirty funnels and vessels in refilling crankcases is often to blame for rapid bearing-wear. Anything that will cause high vacuum in the crankcase should be carefully avoided. Any chance leak between a shaft and its bushing or past the relieved edges of a two-piece bearing will permit the dust to be sucked directly into the bearings. Hence, using flap-valves to cover filler tubes and connecting the breather to the carbureter air-cleaner outlet are usually not considered as being representative of the best practice.

THE INTERNAL-COMBUSTION ENGINE'S REALM

THE steam turbine reigns supreme for all purposes where really high powers are required, such as large electric generating stations and ships of war, while the high-speed internal-combustion engine is rapidly gaining supremacy in forms of locomotion. Unlike the steam turbine, the efficiency of the internal-combustion engine does not increase with size, so that the larger the powerplant the greater is the advantage in favor of steam. The handicap of a lower efficiency does not seriously penalize the steam engine, because it has always been, and doubtless will always be, able to use a cheaper fuel; but this applies primarily to stationary plants. In all forms of transport the internal-combustion engine scores a big advantage, for, though its fuel may cost as much or more, the bulk to be carried is so much less, and the range available without replenishment is so much greater. To this, in many applications, may be added the further great advantage that little or no water need be carried.

It is difficult to see any great future for the stationary or the slow-speed type of internal-combustion engine. In really large sizes it cannot compete with steam, and in the smaller sizes its sphere of utility is being rapidly narrowed down by competition with electricity produced from steam or water in large power stations. It would appear, therefore, that the future of the internal-combustion engine rests with the high-speed type, on the score of lightness and compactness not only of the engine itself but also of the fuel it consumes. This gives it at once an enormous advantage, especially for all forms of locomotion.

It appears astonishing that the internal-combustion engine has not as yet swept the field or even been put to serious use on the railroads. It has been able to compete with steam afloat, where steam has the great advantage of unlimited cold water for condensation, the first essential to efficiency in the steam engine. It has not as yet become a serious competitor on the railroad, where the steam engine is at its greatest disadvantage, since it is forced to work non-condensing and therefore, at a very low efficiency. Further than this, it has to carry not only a correspondingly heavy weight of fuel, but, in addition, nearly 10 times that weight of water. Even for a comparatively short run, the weight of the tender with fuel and water is greater than the aggregate weight of all the passengers carried in a train. This is obviously economically unsound, even where coal is cheap and water everywhere abundant. In countries where coal is dear or water scarce, the continued use of steam for locomotives seems inexplicable, particularly as no insuperable difficulty presents itself to the adaptation of the internal-combustion engine for railroad use. Although gas engines are built in sizes ranging up to over 50-in. cylinder-diameter, the highest efficiency so far recorded has actually been obtained with a gas engine of only 4½-in. cylinder-diameter.

It is well to keep in mind that in the constant-volume type of internal-combustion engine, air is the true working-medium. Unless the air be fully, or almost fully, saturated with fuel, the latter will not burn with sufficient rapidity, while, if an excess of fuel is present, it affects the temperature but little, since it is, of course, the amount of oxygen present, rather than of fuel, that controls the temperature, whatever the fuel may be. The chemical composition and the calorific value of the fuel have only a very small influence on the temperature of combustion. The real governing factor is the amount of oxygen present and the proportion this bears to the nitrogen, which may be regarded as the true medium. The temperature can be changed considerably by varying the proportion of oxygen or inert gases present in the mixture, that is, by creating an artificial atmosphere. Under normal circumstances, however, it cannot be varied over more than a very limited extent by any change either in the quantity or the composition of the fuel or in the density of the charge. In other words, neither change of mixture strength nor of throttle opening can influence the flame temperature, and, therefore, the efficiency, to any appreciable extent. The air consumption of an engine is a true indication of its efficiency as a heat engine, while the fuel consumption may indicate merely a waste of fuel by irregular distribution or defective carburetion.

The popular belief that the inherent efficiency is less at reduced loads owing to the reduced compression is incorrect, for the ratio both of compression and expansion is unaltered. It should remain independent of load, and in practice it does so remain, except for a very slight increase in relative heat loss, provided that the mixture is the same and the ignition correctly timed. The efficiency reckoned on the brake horsepower will, of course, fall as the load is reduced owing to the larger proportion that the mechanical losses, and these may be taken as being practically constant, bear to the total indicated-power. That is to say, it should diminish merely as the mechanical efficiency diminishes. The loss of heat to the cylinder-walls has nothing like the influence generally attributed to it, and in the case of a well-designed engine the complete suppression of all heat loss to the cylinder-walls would increase the power and efficiency by about 7 per cent only.—From a resume in *Automobile Engineer* of lectures delivered by Harry R. Ricardo at King's College, London.

The Significance of Common Physical Properties of Structural Materials

By F. H. Moore[1]

Buffalo Section Paper *Illustrated with* Drawings

ABSTRACT

THERE is danger that a code of standard specifications for materials of construction, while advantageous, will cause engineers, designers and inspectors to neglect the significance of various requirements of the specifications. The danger of such neglect is greatest when considering new materials, as it is not certain that properties that would make a new material suitable for a specific purpose would be revealed by the same kind of physical test that serves for a known material. The author summarizes his views as a testing engineer regarding the significance of the results of some of the common physical tests that are applied to metals, with the expectation and the hope that the statements will arouse discussion.

In drawing specifications for materials, a sharp distinction is made between elastic-limit and yield-point, yet both are somewhat arbitrary determinations of stresses in which the material changes from elastic action to plastic action. With many materials, however, the elastic-limit does not mark a definite point below which perfectly elastic action with no damage from any number of repetitions of stress takes place. After a single loading that involves the inelastic action, the elastic-limit is changed. The microscope reveals, also, that materials differ widely in homogeneity and in strength in all directions. The idea of an absolute elastic-limit must be abandoned.

Comparison of the elastic-limit and the yield-point gives a fairly reliable index of internal strains in steel. The elastic-limit marks the practical limit of static-strength of metals having a fairly well-defined elastic-limit but no clearly-defined yield-point. It is of little significance in the structural use of brittle materials. The yield-point is an index of the static-strength of materials having a well-defined yield-point.

Tensile-strength is significant as an index of the static-strength of metals and other materials. It gives a fair idea of the elastic-strength of most grades of wrought steel and of the resistance of wrought ferrous metals to repeated stress or fatigue.

Compressive-strength is of value as indicating the static-strength of brittle materials and of the ability of short parts to withstand static compressive-loads, but in a long structural part a compressive-load may induce a flexural action, with tensile-stress on one side of the piece, so that the real measure of strength is the tensile-strength rather than the compressive-strength.

Shearing-stresses and shearing resistance of materials used in structural and machine parts have not received the attention they deserve. The shearing-strength of ductile materials is best determined by torsion tests, and a metal the shearing-strength of which is greater than its tensile-strength may be regarded as brittle. If, in a torsion test, a specimen fails squarely across its axis, the failure is a shearing failure, whereas, if the failure is along an inclined plane, it is a tension failure.

Ball-impression tests for hardness give a fairly reliable index of the tensile-strength of most metals and of the strength of wrought ferrous metals under repeated stress. This test, however, has not proved of value as an index of cutting-hardness nor of resistance to abrasion.

Tests of notched-bar specimens by a single blow from a swinging pendulum or by a falling weight do not give an idea of static-strength nor of the resistance of a metal to repeated stress, and the significance of the results never has been established clearly. The fatigue or endurance-limit seems to be a reliable index of the ability of a material to withstand oft-repeated stress of a given magnitude but, taken alone, is not an index of the resistance to occasional overstress followed by oft-repeated normal stress. The method of making accelerated tests of the endurance-limit of metals by using a high nominal stress and comparing the relative values of the length of endurance of different metals seems utterly unreliable, as contradictory results can be obtained.

The repeated-impact test with notched specimens may be of value for a given material for a specific purpose with a certain design of machine but the result would not have significance for any other material or with any other design of machine, because, with a notched specimen and with a load applied by blows, no accurate computation of stress can be made and, moreover, it is difficult to interpret strength values in terms of "life" or endurance.

Ductility is not a direct measure of either static-strength or strength under repeated stress, yet it is a quality that furnishes insurance against shattering collapse immediately following elastic failure and also tends to prevent the formation, under accidental overloads, of minute cracks that would spread under succeeding normal stresses, weakening the member and causing a fatigue failure. The best index of ductility in materials is given by the measurement of elongation and reduction of area of fractured test-specimens. The ductility of sheet material is indicated best by some form of cupping test. Test results do not bear out the common belief that ductile materials will resist repeated stress better than brittle materials.

A CODE of standard specifications for the various materials of construction is being developed rapidly in the United States. The development of that standardized code has many advantages. Yet it has at least one danger. That danger is that testing engineers, machine designers, architects, structural engineers and inspectors will form the habit of asking merely, Does a given material "pass" or "fail" by the standard of the current specification? and will grow out of the habit of asking themselves, What is the significance of each of the various requirements of the standard specification?

This danger is especially great when new materials are being considered for use. It is not at all certain that the good or the bad properties of a new material

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will be revealed by the same kind of physical test that served satisfactorily for a known material. There is no certainty, for example, that the standard physical tests for structural steel can be used, unmodified, to determine the suitability of aluminum for structural use. Nor is it certain that the same tests that are used for burnt-clay brick should be used to separate the "sheep" from the "goats" in a shipment of sand-lime brick.

Moreover, the natural tendency is to place reliance on the results of any series of tests made with an accurate and delicate machine that gives consistent results which can be tabulated nicely. This sort of reliance frequently has been placed on the results of "drop tests" and other impact-tests from which beautiful tabulations of data can be made but which significance in my opinion is by no means certain.

Notable exceptions to the last statements are found in the cases of the work of Dr. F. C. Langenberg, of Watertown Arsenal, and of Dr. D. J. McAdam, Jr., of the Naval Engineering Experiment Station.

An endeavor is made herein to summarize very briefly my views as to the significance of the results of some of the common physical tests of materials of construction, especially the tests of metals. Such a concise summing-up inevitably will sound somewhat dogmatic, but it is hoped that the paper will be taken merely as expressing the views of a testing engineer who has been connected for several years with a laboratory engaged in a rather wide variety of research and commercial testing, the Materials Testing Laboratory of the University of Illinois. I hope, and expect, that this paper will stir up discussion.

Elastic-Limit and Yield-Point

In careful technical writing and in carefully-drawn specifications it is customary today to distinguish rather sharply between elastic-limit and yield-point. This is, in my opinion, a distinction between test methods of different degrees of delicacy rather than between two different physical properties. Both the elastic-limit and the yield-point are somewhat arbitrary determinations of stresses in a limiting region in which the action of a material under stress changes from elastic to plastic action. For some materials, notably wrought ferrous metals free from internal stress, this limiting region covers a narrow range of stress; for other materials, notably rubber, elastic and plastic action are both present in marked degree under almost any stress from zero to the breaking-point.

The texts on the mechanics of materials have, for the most part, been written with the action of metals in mind and have given the impression that the elastic-limit of a material is a definite stress below which the action under stress is perfectly elastic and below which no structural damage is caused by any number of repetitions of stress. This concept is not exact, even for wrought ferrous metals, and is far from true for some materials of construction. By the use of very delicate instruments, inelastic action can be detected at low stresses, even for steel. After one loading involving inelastic action, the elastic-limit found for a metal is changed, sometimes increased, sometimes decreased, according to the method of carrying out the test. Moreover, when the structure of materials as shown by the microscope is considered, it is seen how widely actual materials differ from the state of homogeneity and equal stiffness in all directions which is assumed in developing the formulas of the mechanics of materials. In my opinion, the concept of an absolute elastic-limit for materials, even for metals, must be abandoned; and attempts to find an elastic-limit by the use of extremely delicate apparatus are of doubtful value, except for a special purpose noted later.

However, although the elastic-limit must be recognized as a somewhat arbitrary value that is dependent on the method of determination, it has a marked significance to the user of structural material. If not determined too delicately, and by this it is not meant to imply that it may be determined without care, the elastic-limit marks the practical limit of static-strength for many machine and structural parts as, for example, short compression-members and dead axles. For brittle materials, such as cast iron, the elastic-limit is a purely arbitrary value of no great significance in structural use; for timber, the significance of the elastic-limit seems to be intermediate in importance between its significance for wrought metals and its non-significance for cast iron or for concrete.

A comparison between the elastic-limit of steel as determined by delicate test-methods and the yield-point for the same steel, determined, as it is, by rather crude methods, gives what seems to be a fairly reliable index of the internal strains present in the metal. A stress-strain diagram like that at the left of Fig. 1 is characteristic of steel with high internal-strains, which, as the load is increased on the specimen, gradually cause the most-stressed fibers to yield, whereas a stress-strain diagram like that at the right is characteristic of steel with low internal-strains. A word of caution is necessary in this connection; a specimen of steel with low internal-strains may give a diagram like that at the left of Fig. 1 if the test-specimen is not loaded axially in the testing-machine; that is, if proper self-centering shackles are not used.

For materials possessing a well-defined yield-point, the yield-point is, in my opinion, an excellent index of the static-strength of the metal. The principal objection to the use of the yield-point for such an index lies in the large personal factor inherent in its determination. I believe that yield-point should be reported only for tests that show a very clearly marked "drop of beam," and that such tests should be run at slow speeds, especially for metals other than steel. The allowable speeds given in the standards of the American Society for Testing Materials represent the extreme of good practice for steel; for other metals, and for any but highly-skilled operators, the speed should be lower than the values given in the standards of that Society.

To recapitulate, my opinion is that, for metals having a well-marked yield-point, the yield-point indicates the beginning of serious plastic action under stress and fixes the practical limit of static-strength of such metals for use in most structural members and machine parts. For metals having no clearly defined yield-point but with a fairly well-defined elastic-limit, the elastic-limit, which should not be too delicately determined, fixes the practical limit of static-strength for most machine parts and structural members. A comparison of a carefully determined elastic-limit with the yield-point seems to be of value as an index of the internal strains in the metal.

Tensile-Strength

The tensile-strength of a material, determined, as it is, from the maximum load carried during a tension test of a specimen, is a well-defined property of nearly all materials. It is of direct significance as an index of the static-strength of such materials as rope, fabrics and rubber, and of metal to be used in chains, bolts and

tie-rods. It is not of direct significance, however, as an index of strength of metal to be used in most structural and machine parts, because such members, in most cases, cease to perform their structural duty long before the tensile-strength is developed; nevertheless, the tensile-strength is of indirect significance in many such cases. The relation of yield-point to tensile-strength is fairly constant for most grades of wrought steel, and the tensile-strength gives a fair idea of the elastic-strength.

For wrought ferrous metals that are free from serious internal defects, the tensile-strength is also a fair index of the resistance to repeated stress or fatigue. The fatigue of metals under repeated stress seems to be a progressive fracture rather than an elastic failure. Whether this relation holds for castings and for non-ferrous metals is at present uncertain; but it is fairly certain that for non-ferrous metals the ratio of strength to resist repeated stress to static tensile-strength is less than the ratio for wrought iron and steel.

A word of caution is necessary in regard to the determination of tensile-strength for brittle materials. It is very difficult to design, shape and test a tensile-test specimen so that the stress at the middle of the specimen will be distributed uniformly over the cross-section and so that the specimen will be free from high localized stresses at the roots of threads or at other points of attachment to the shackles of the testing machine. For ductile metals, these localized stresses cause merely local yielding and the value determined for tensile-strength is not greatly affected, but for brittle materials the failure is frequently caused by such secondary stresses. To be of value, the tensile-strength of brittle materials must be determined with great care by the use of very perfectly formed specimens.[2]

Compressive-Strength

The compressive-strength, which is analogous to the tensile-strength, is of value as an index of the static-strength of brittle materials. It is a question whether the compressive-strength of a brittle material is not really a measure of shearing-strength, but in any event it is a good index of the ability of short parts made of such material to withstand static compressive-loads. It should be noted that in a long structural or machine part a compressive-load may set up a flexural action with consequent tensile-stress on one side of the piece, and that under such circumstances it may be the tensile-strength of the material that is the measure of its strength. For compressive tests of brittle materials, the remarks made on tension-testing concerning the necessity of careful machining of specimens and careful technique of testing are applicable. Ductile materials have no well-defined compressive strength.

Elastic-Limit in Shear and Shearing-Strength

The shearing stresses in machine and structural parts and the shearing resistance of materials used in such members have not received the attention they deserve at the hands of testing engineers. For ductile metals, the shearing-strength is best determined by torsion tests. The significance of elastic-limit in shear is analogous to the significance of elastic-limit in tension; the elastic-limit may be regarded as the practical limit of static-strength for the material in most machine parts and structural members that are subjected to direct shear or to torsion.

[2] See Report of the British Aeronautical Research Committee for 1921.

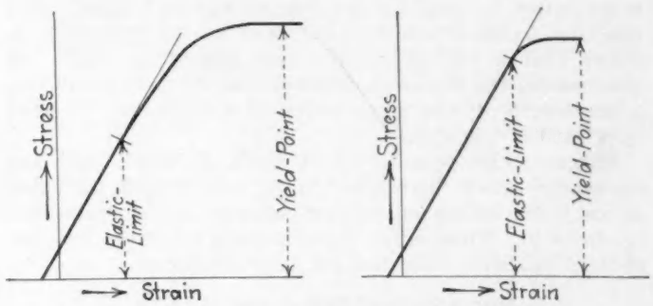

Fig. 1—How Internal Strains Affect Physical Characteristics
A Stress-Strain Diagram like the One at the Left Is Characteristic of Steel with High Internal Strains Which, as the Load Is Increased on the Specimen, Causes the Most Stressed Fibers To Yield. A Stress-Strain Diagram like That at the Right Is Characteristic of Steel with Low Internal Strains

For brittle materials, the shearing-strength is not a particularly significant property and there is no commonly-used reliable method of determining it. A fairly reliable method of separating brittle from ductile metals is, in my opinion, to take as brittle those whose shearing-strength is greater than their tensile-strength. A quick method of testing this ratio in a qualitative way is to make a torsion test of a specimen of the metal. If it fails squarely across the axis of the specimen, the failure is a shearing failure and, since in a torsion test the magnitude of maximum shearing-stress is the same as the magnitude of the maximum tensile-stress, at 45 deg. to the axis, a shearing failure in torsion shows that, judged by the specimen tested, the shearing-strength of the material is less than its tensile-strength. If the torsion specimen fails along an inclined plane, the failure is a tension failure and the shearing-strength is greater than the tensile-strength.

From texts on the mechanics of materials it is learned that, for any structural or machine part subjected to direct shear or to torsion, the maximum tensile-stress on some inclined plane is never less than the maximum shearing-stress developed. So, for parts made out of brittle metals whose tensile-strength is less than their shearing-strength, there is practically always greater danger of tension failure than of shearing failure. For materials having a well-defined grain, like wood, the shearing-strength along the grain is frequently a deciding factor in the strength of a machine part or structural part, and is an important physical property of the material.

Ball-Impression Hardness-Tests

The Brinell and the later Rockwell tests for a property called "hardness" have come into wide use in recent years. In these tests the value given for the hardness of the material is measured inversely by the dimensions of the impression left by a standard steel ball pressed against the surface of the material with a standard load. These tests are made quickly and cheaply and, being non-destructive tests, can be applied to finished articles. They are arbitrary tests in which the value has been proved by experience. The ball-impression test gives a fairly reliable index of the tensile-strength for most metals, and for wrought ferrous metals gives a fair index of the strength under repeated stress. Just why this correlation exists has never been explained satisfactorily, but a considerable amount of test data now exists which give good evidence that it does exist, at least for steel up to a Brinell hardness of about 375. The value of ball-impression-test results for cast metal, concrete and timber is now the subject of study. Of course, such

tests cannot be used for textiles, rubber or leather. For machine parts which are so small or so irregular in shape that a ball-impression test cannot be used, the scleroscope, the Rockwell tester or the Herbert pendulum gives results of the same order of significance, if used by a skilled operator.

Rather oddly, none of these tests, although they are commonly called "hardness" tests, has proved its value as an index either of cutting-hardness or of resistance to abrasion. Thoroughly reliable tests for these two important qualities have not yet been developed.

Notched-Bar Tests for Metals

I have purposely avoided the use of the term "impact" in the heading of this division of the paper. "Impact" is a term used in connection with a number of widely differing cases of rapidly applied load. The tests here considered include Charpy, Izod and other tests in which a notched specimen is broken by a single blow from a swinging pendulum or from a falling weight, the energy required to fracture the specimen being indicated in some way. As the specimen is notched, no accurate computation of stress in the specimen is possible and the test results are purely arbitrary, depending almost entirely on the dimensions and the shape of the specimen and especially those of the notch.

The significance of the results of notched-bar tests is not at all clearly defined. Notched-bar tests certainly do not give an idea of static-strength, nor of the resistance of a metal to repeated stress. The shock applied is so violent that no index of the ability of the material to resist any ordinary service shocks is given, unless it be for material to be subjected to very violent shocks, such as material for rifle barrels and for cannon. The notched-bar test is claimed to be useful as a detector of certain supposedly injurious heat-treatments in steel; however, in spite of the rather wide use of notched-bar tests, the significance of their results has never been clearly established. In the words of the metallurgists of a large fabricator of steel parts, "the notched-bar test is an excellent test to determine whether steel will pass the notched-bar test."

"Fatigue"-Test Results

The ability of material to resist millions of repetitions of working stress is obviously an important property for many machine parts and for a few structural parts. The obvious test to determine this property consists in subjecting specimens of the material to repetitions of known stress. The commonest fatigue-test now in use applies cycles of reversed flexural stress to a specimen by a machine similar to that shown in Fig. 2. In this machine the specimen is a rotating beam. For any position of the beam, the top fibers of the specimen are in compression and, as the specimen rotates one-half of a revolution, the stress is changed to tension. The specimen may be either a centrally loaded beam, as shown, or may be a cantilever beam, in which case the tension fibers are at the top. A series of tests is required to determine the resistance of a material to repeated stress. First, a specimen is run at a high stress and failure occurs after a few thousand revolutions of the testing-machine. Then a specimen is run at a lower stress, and its "life" is much longer than that of the first specimen. Additional specimens are run with successively diminishing stress and a diagram is plotted to a logarithmic scale for convenience, using values of stress as ordinates and values of number of cycles necessary to cause failure as abscissas, giving what is called an *S-N* diagram. After a number of specimens have been tested, a stress is found for which the direction of the *S-N* diagram changes sharply, as shown in Fig. 3, which is a typical *S-N* diagram for steel. For the wrought ferrous metals, specimens run at lower stresses will run apparently to an indefinitely large number of cycles of stress without fracture; specimens at stresses just below this limit have run to 1,000,000,000 cycles. This limit of stress is called the *endurance-limit* or the *fatigue-limit*.

For wrought ferrous metals, the endurance-limit usually can be determined by tests to 5,000,000 cycles of stress, but for non-ferrous metals it seems necessary to run tests to at least 100,000,000 cycles of stress, and even then the endurance-limit is not nearly so clearly defined as for wrought iron and steel.

The determination of the endurance-limit by such a series of tests is a slow and costly affair and consequently various accelerated tests for endurance-limit have been proposed. One of the commonest methods is to make endurance tests of different metals by using a high "nominal" stress and comparing the relative values of the length of endurance of the different metals. This method seems utterly unreliable as a measure of the ability of a metal to resist millions of cycles of working stress. The contradictory results that can be obtained from such accelerated tests are illustrated in Fig. 3, where the heavy line is the *S-N* diagram for a normalized high-carbon steel and the light line is the *S-N* diagram for cold-drawn steel. If a comparison of length of endurance were made at a nominal stress of 60,000 lb. per sq. in., the cold-drawn steel would be judged the better metal. If a comparison of the length of endurance of a nominal stress of 50,000 lb. per sq. in. were made, the metals would be judged to be of about equal value. If a comparison of the length of endurance of a stress of 45,000 lb. per sq. in. were made, the normalized high-carbon steel would be judged the better metal. Obviously, a test that is capable of such contradictory interpretations is not reliable.

Accelerated tests have been proposed in which a rise of temperature under cycles of repeated stress, or an abnormal deflection under cycles of repeated stress, is taken as an indication of the endurance-limit. So far, such tests seem to give reliable results for some metals but not for all, and their limitations and possibilities are still a matter for study.

As suggested in a previous paragraph, for wrought ferrous metals up to a Brinell hardness of about 375 a fairly good correlation seems to exist between the endurance-limit and the tensile-strength and between the endurance-limit and Brinell hardness. In a general way, the endurance-limit for wrought ferrous metals under cycles of reversed flexural stress is about one-half the tensile-strength and about 250 times the Brinell hardness-number. Under cycles of reversed axial stress, tension-compression, the endurance-limit for wrought ferrous metals is about two-thirds of the endurance-limit under cycles of reversed flexural stress. Very recent tests indicate a much higher ratio if extreme care is taken that the axial-specimen has purely axial loading. Under cycles of reversed shearing-stress, the endurance-limit for wrought ferrous metals is about 55 per cent of the endurance-limit under cycles of reversed flexural stress. The endurance limit has no apparent correlation with the results of the Charpy or the Izod test, and no direct correlation with ductility. The indirect relation of the endurance-limit to ductility is discussed in a later paragraph.

The endurance-limit seems to me to be a reliable index

of the ability of a material to withstand oft-repeated stress of a given magnitude. Taken alone, it is not an index of the resistance of a material to occasional severe overstress followed by oft-repeated normal stress.

Test-Results from Repeated-Impact Tests

A test that has had some vogue as a control-test for material for automobile parts is a repeated-impact test in which a notched specimen is subjected to a series of light transverse blows, the specimen being turned 180 deg. between each two blows. The number of blows required for fracture is taken as an index of the value of the material. It is evident that, with a notched specimen and with a load applied by blows, no accurate computation of stress can be made, and that this test gives arbitrary values. Moreover, it is always difficult to interpret strength values in terms of "life" of the specimen. This test may be of value for a given material for a given use with a given design of machine and of specimen, but it could not be stated that for any other material or with any other design of the machine the results would be of significance.

The particular form of machine and of specimen used with what is sometimes known as the Stanton test is thought by a well-known British firm of automobile manufacturers to be an excellent control-test for automobile steel. They characterize this particular repeated-impact test as less severe than the Izod or the Charpy test and more severe than the rotating-beam fatigue-test. The repeated-impact test can be varied from a test resembling an Izod or a Charpy test to one resembling a rotating-beam fatigue-test by varying the energy of the blow used.

Ductility Tests and Their Significance

Three tests for ductility of metals are in common use. They are cold-bend tests and measurement of elongation and reduction of area after tensile fracture. Cold-bend tests are evidently intended for field use where elaborate testing apparatus is not available. I can see little object in refining such tests and in using expensive apparatus to make them. If rough field-tests will not serve to measure ductility, why not have a regular tension-test and measure elongation and reduction of area? In this connection, however, I wish to suggest that, for control-tests of many structural and machine materials, the use of the Brinell or the Rockwell test, as an index of strength, and of a simple cold-bend test to give a rough

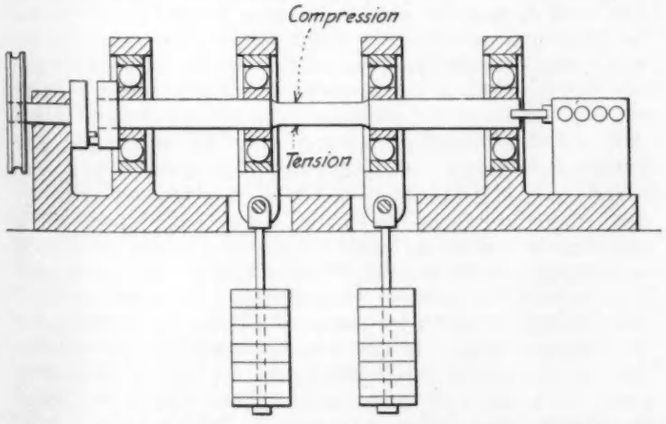

Fig. 2—Diagram of the Rotating-Beam Type of Testing Machine for Tests under Reversed Stress

In This Machine the Specimen Is the Rotating Beam That Is Centrally Loaded as Shown. For Any Position of the Centrally-Loaded Beam, the Top Fibers of the Specimen Are in Compression and, as the Specimen Rotates a Half Revolution, the Stress Is Changed to Tension

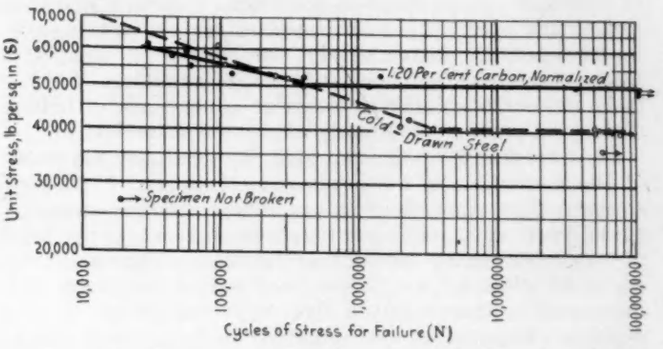

Fig. 3—Test Results for Cold-Drawn and 1.20-Per Cent Carbon Steel

The Results Plotted Were Obtained with the Testing Machine Illustrated in Fig. 2. A Specimen Is First Run at a High Stress to Determine Its Resistance to Repeated Stress, and Failure Occurs after a Few Thousand Revolutions. Then a Test Is Run at a Lower Stress and Its "Life" Is Much Longer than That of the First Specimen. Other Specimens Are Tested at Successively Diminishing Stresses and a Diagram Is Plotted Using the Value of the Stress as Ordinates and the Number of Cycles Necessary To Cause Failure as Abscissas

index of ductility, might be found very much worthwhile. Such tests might well be used for reinforcing-rods for concrete, for example.

The measurement of elongation and of reduction of area of fractured tension-specimens seems to give the best index of ductility for the material in plates, shapes, rods, forgings and steel castings; some form of "cupping-test" seems to give the best index of ductility for sheet material. If the results of tests of elongation for two materials are to be compared, it is important that the specimens be geometrically similar. This similarity is not so important for comparing values of percentage of reduction of area but still is desirable.

But what is the significance of ductility? The opinion is often expressed that ductile materials will resist repeated stress better than will brittle materials, even though the brittle materials be statically stronger. Test results do not bear out this opinion. Brittle, hard steel withstands millions of repetitions of stress that would snap ductile wrought-iron or soft steel after a few hundred repetitions. Ductility is not a direct measure of either static-strength or strength under repeated stress. Nevertheless, ductility in a metal is a very valuable quality. As I see it, the value of ductility is two-fold; (*a*) ductility furnishes insurance against shattering collapse immediately following elastic failure and (*b*) if a machine or structural part is subjected to a few accidental heavy overloads, and very many machine and structural parts are occasionally overstressed, ductility tends to prevent the formation of minute cracks that spread under succeeding cycles of normal stress, weakening the member and finally causing a fatigue failure.

Under (*a*), it is of interest to compare the failure of a short steel strut with the failure of a cast-iron strut. After the yield-point of the steel strut is passed, serious distortion occurs and the piece ceases to perform its structural duty, but no sudden shattering collapse occurs, as is the case with the cast-iron strut. Moreover, in the steel strut localized overstress can occur at bearing points or around rivets without much damage to the strut as a whole. Any localized overstress in the cast-iron strut is likely to cause shattering failure of the whole strut.

Under (*b*), recent tests both in England and in this country have shown that, under repeated stress, small holes in specimens of ductile metals do not cause so great a weakening as is indicated by the mathematical theory

of elasticity; small holes in specimens of brittle material reduce the strength under repeated stress more nearly by the amount indicated by the theory of elasticity. Deep scratches, notches and sharp shoulders involve more danger of failure in machine parts made of brittle material than in parts made of ductile material.

It is frequently forgotten that the ordinary formulas of the mechanics of materials neglect scores of localized stresses that exist in ordinary structural and machine parts, such as stresses at the roots of threads, the root of keyways, sharp shoulders, bearing points and the edges of rivet-holes. These localized stresses are not infrequently from two to five times as great as the stresses computed by the usual formulas. Under static loading they are not important for ductile materials in which they cause minute distortion, which is negligible, but under repeated loads these localized stresses are not negligible even for ductile materials, though they do less damage to parts made of ductile material than they do to parts made of brittle material.

To sum up, it is my opinion that insistence on ductility in material for structural or machine parts, as measured by elongation or reduction of area, is justified, not as an assurance of strength, but as an insurance against sudden shattering fracture under static load, and as partial protection against reduction of "fatigue" resistance by occasional accidental overload.

I wish to repeat that, while the concise summary of opinion here presented sounds rather dogmatic, it is given as opinion, much of which has been acquired in very recent years, and that it is hoped that this statement of opinion will give rise to discussion of the significance of the common physical properties of structural materials.

THE DISCUSSION

L. H. POMEROY[3]:—Professor Moore's service in putting so clearly before automotive engineers the limitations of commercial material-testing processes is of the greatest value and importance. The last 20 years has inflicted upon the engineer and metallurgist a welter of testing methods, nearly all of them based upon what happens after the yield-point is exceeded while very few relate to the actual happenings of practice. After this agonizing process, to what does it all amount? Simply that the only thing we know certainly about a material is its ultimate tensile-strength.

As an engineer with sufficient experience in design to know something about failures, I regard most tests with the utmost suspicion. That results on test-pieces have some importance as indicating, for example, that a nickel-chromium heat-treated test-piece may or may not have a tensile-strength greater than a similar test-piece made of cast iron is, of course, very true. But, on the other hand, the development of test-piece metallurgy has caused a great amount of money to be spent needlessly, because it is an article of faith on the part of most metallurgists that if one test-piece is, for example, stronger than another, it is, ergo, more suitable for a given job in which strength is required.

Unfortunately, in engineering generally, and in automotive engineering in particular, stiffness is as a rule more important than strength, hence the virtues of a nickel-chromium crankshaft in point of strength are entirely offset by the fact that considerations of stiffness completely mask those of strength. The only part of an automobile of which I can think offhand in which the use of an alloy-steel is justifiable is the spring, the material of which is stressed very nearly to its elastic-limit.

Another important aspect of the use of materials is that of stress distribution. Large fillets are vitally important. When one sees an expensive alloy-steel crankshaft, connecting-rod or rear-axle shaft subjected to local stresses that are hundreds per cent higher than the average through the use of small fillets, sharp keyways and the like, the molten steel in its crucible must feel frozen with horror. It seems to be one of the curses of American production methods that, if the machine-shop authorities can possibly find an excuse for eliminating a fillet, they will surely do so.

I am greatly pleased to note Professor Moore's advice that a reasonable degree of ductility should be encouraged. The practical evidence in support of this is overwhelming in my opinion.

My experience with materials in general is that physical tests are relatively unimportant compared with microphotography and chemical analysis. I am speaking, of course, of the practical case in which a manufacturer wants to insure that all alleged heat-treated 40-carbon steel is such and no other, but does not want to compare one steel with another. Apart from this practical case, he would be a rash man who would be prepared to guarantee the replacement of one kind of steel by another on the basis of any or all known physical tests.

TEST RESULTS WITH CASE-HARDENED STEEL

JOHN MILLER[4]:—I would like to congratulate Professor Moore on his splendid work in the testing of steel, and particularly on endurance testing. I believe that the notched impact-test, taken alone, is not of much value, but, taken in conjunction with the Brinell test, it possesses considerable value. The notched impact-test will detect brittleness, which is sometimes not shown by any other test. Hardness seems to be necessary where high endurance-properties are desired. As Professor Moore said, the Brinell and impact tests are simple and easy to make.

Most failures of parts on cars and trucks are due to severe localized stress from overloads. The careful driver does not have much trouble. The man who overloads is the one who breaks down the material.

The Stanton test is good for severe localized stress. In using it, I have been surprised by the remarkable results that can be obtained with case-hardened steel. A piece of mild steel, having a Brinell hardness value of 170, will withstand something like 10,000 blows under the Stanton test with a 1-in. fall. A piece of alloy-steel heat-treated to give the very best results, and registering 375, on the Brinell test, will withstand about 50,000. A piece of properly case-hardened mild steel, with a Brinell hardness of 555, may withstand as many as 500,000 blows. Case-hardened alloy-steel will run higher still. It seems to me that this is a noteworthy and important property in case-hardened steel. The remarkable results are due, probably, to the resistance to deformation of the other fibers and to the absence of high internal-stresses. I have taken a piece of tool-steel and hardened it to the same degree that is obtained in case-hardening. It lasted about 2000 blows. That is due to the high internal-stresses in the high-carbon steel. I would like to have Professor Moore's opinion on this.

HARDNESS TEST WITH TRIANGULAR POINT

C. H. BIERBAUM:—I would like Professor Moore to explain the comparative advantages between the Brinell

[3] M.S.A.E.—Consulting engineer, Buffalo.
[4] M.S.A.E.—Metallurgist, Pierce-Arrow Motor Car Co., Buffalo.

and the Rockwell tests. The first uses a ball, whereas I understand a cone point is used in the Rockwell, in which the same proportional conditions are supposed to exist from beginning of application of load to the end, whereas in the Brinell, it is purely compression at the beginning.

Instead of a cone, I have used a corner of a cube having the diagonal of the cube normal to the surface, making a three-cornered impression. It is then a question of flow and shear from the beginning and the indentation can be read with absolute exactness. This is not the case with the Brinell test. The results are very different under different tests and different impressions with non-ferrous metals. If we make this three-cornered indentation with a series of increasing loads, plot them and take the point at which the curve becomes a straight line, we obtain a definite characteristic of the metal. It does not seem that either the Brinell or the Rockwell test would give such results.

MR. MILLER:—I have had some experience with the Rockwell machine. Its principal advantage is in testing small light specimens that it is impossible to test with the Brinell machine.

MR. BIERBAUM:—Then it requires a curve to make a comparison.

MR. MILLER:—Yes.

MR. BIERBAUM:—Recenty, in published results, I have come across some curious tests. I think the Brinell tests were taken on too small a surface. The same thing occurred in our own laboratory, where Brinell tests were made on the outside edges of the timing-gears for automobiles and on the end of the hub. The castings were all too soft. I then took one of these castings, cut off the hub and trebled the area on which the ball was used and they tested too hard.

STANDARD SPECIFICATION TOO INDEFINITE

PROF. F. N. MENEFEE:—With reference to testing, Professor Moore is a man who apparently has a different view. I think he can do much to clarify varying ideas. Considerable trouble was experienced with materials during the war. Some would pass at Baltimore and could not pass at Youngstown. Today we have similar difficulties. That is due largely to the way the specifications of the American Society for Testing Materials are written. They do not seem to have that sharpness and definiteness that they should possess. As an illustration, a young man leaving school wants to know what elastic-limit really is. The American Society for Testing Materials says, "Elastic-limit is that point beyond which, if you continue the load, the material will take a permanent set." Then he looks at proportionality-limit and finds that it is the point at which stress and strain cease to be proportional. I do not see how the boy can distinguish between the two. When you get the condition in which you no longer have proportionality, you have a permanent set, and so on. None of the standards of our National societies is perfect, but we could improve these American Society for Testing Materials Standards. I know of thousands of records in the City of Washington where the tensile-strength was obtained by dividing the load at breaking by the original cross-sectional area, whereas others today are using the maximum load sustained by the test-piece divided by the original cross-sectional area. The preprint of the report of Committee E-1 on Methods of Testing, for the June, 1924, meeting of the American Society for Testing Materials reads:

> *Tensile-Strength.*—The maximum tensile-stress that a material is capable of withstanding. Note:—In practice, it is considered to be the maximum stress carried by the specimen representing the material in a tension test to rupture, under definite prescribed conditions.

I do not believe anyone is absolutely sure, from the foregoing, what tensile-strength is. The definition is not definite enough.

ALDEN MERRILL:—Professor Moore was asked about what experience anyone might have had with the various machines, the Rockwell machine particularly. The results we have obtained with any given machine seem to be very concordant. As with the scleroscope, one operator on two different machines obtains results that are entirely different and cannot be directly compared, although, with one operator and one machine, the tests are very consistent. The instrument is extremely sensitive.

W. R. GORDON[5]:—One thing that has not been touched on tonight is the use we make of different materials to alloy with the steel to obtain certain results. We add chromium, molybdenum, nickel and the like. I would like to ask just what happens to the structure of the steel when these materials are added.

PHYSICAL TEST MAY BECOME A FETISH

PROFESSOR MOORE:—Mr. Pomeroy feels that the importance of physical tests of metals has been somewhat over-rated. He expressed the opinion that in many automobile parts stiffness counts rather than strength. Both statements undoubtedly are true, yet, if stiffness alone were considered, automobile parts could be made of very soft steel, which has the same modulus of elasticity as heat-treated alloy-steel. Everyone will recognize that this would not work well and that strength certainly is important in the material for automobile shafts, connecting-rods and gears. Neither strength nor stiffness can be predicted by chemical analysis alone. Microscopic examination is very useful in judging the physical qualities of steel, but it does not lend itself to the formulation of quantitative specifications. It is very easy, however, as Mr. Pomeroy says, to make a fetish out of a routine physical test.

In connection with Stanton tests, it is to be noted that one metal cannot be considered 10 times as good as another because it stands 10 times the number of blows in the Stanton machine. Above the fatigue-limit, the number of cycles of stress necessary to break a specimen varies inversely about as the eighth power of the stress. A decrease of 10 per cent in the stress increases the number of cycles required for fracture about 2½ times, so a very slight change in the stress makes a very large difference in the life. Furthermore, an arbitrary test like the Stanton test may be useful in separating satisfactory from unsatisfactory metal for a special service, say for automobile axles, and yet be very unsatisfactory if used to separate good metal from bad for a different service.

ADVANTAGES OF HARDNESS TESTS

Mr. Bierbaum raised the question of the advantages of various kinds of so-called hardness tests. I have not had experience with the Rockwell tester and cannot give any estimate of its value. It would seem worthwhile to note that, in addition to the Brinell test, the Rockwell test and the scleroscope, the "Baby" Brinell tests, using a very small ball, and the new Herbert pendulum-test, have been developed. The last-named is interesting in that the indentation is measured by its effect on the time of swing of a pendulum pivoted on the ball or the jewel

[5] M.S.A.E.—Truck experimental engineer, Pierce-Arrow Motor Car Co., Buffalo.

point that makes the indentation. Attention should also be called to the hardness test proposed by Prof. Parker Haigh, of the Royal Naval Academy at Greenwich, England. His test consists of pressing together two rectangular specimens of metal so placed that the edges of the specimens cross each other at right angles. The resulting indentations are measured. This test eliminates the use of a ball or a jewel point of supposedly standard shape and hardness. The main point in this connection is that even so arbitrary a test as the Brinell test seems to be useful in estimating both static and fatigue-strength of steel.

Professor Menefee questioned the advisability of separate definitions for elastic-limit and for proportional-limit. In the latest tentative standards of the American Society for Testing Materials, which are just off the press, it will be seen that only elastic-limit is given a definition and that it is stated that for practical purposes the elastic-limit can be determined by determining the limit of proportionality of stress to strain in the test specimen.

The Role Played by Alloys

Mr. Gordon inquired what role is played by various alloying elements in steel. I am a testing engineer and not a chemist nor a metallurgist, but I will discuss this point with some hesitation and attempt to give the testing engineer's view.

The effect of each of the common alloying-elements, nickel, chromium, manganese and molybdenum, seems to be primarily to slow down the rate of transformation of crystalline structure in steel as it passes through the critical range of temperature. Under laboratory conditions and extremely careful control of temperature, it seems possible to get as high static-strength and as high fatigue-strength from plain carbon-steels as from alloy-steels. In practice, however, the alloying elements allow much more variation in heat-treatment without danger of serious damage to the steel, and many of the alloy-steels, after a heat-treatment, also retain a high degree of ductility that gives a good degree of strength. So far, I have seen no reason to consider that one kind of alloy was markedly superior to any other kind. As much variation in quality can be obtained by variation in heat-treatment as can be obtained by variation in alloying elements.

Another advantage of alloy-steel is that the presence of alloying elements permits the effective heat-treatment of rather large pieces of steel. If a large piece of plain carbon-steel is quenched from a red heat, the outside is cooled suddenly but the inside is not, and the inside takes on the structure of normalized steel. In a large piece of alloy-steel, the transformation takes place more slowly, and the steel is cooled clear to the center before the transformation to the normalized state is complete. Hence, the quenched alloy-steel has more uniform strength and hardness than has the quenched carbon-steel.

OIL RESERVES

At various times in the past estimates have been made of the oil reserves in this Country based on the record of producing wells and extensive field investigations in new territory, and indicating that our resources would be exhausted in 10, 15 or, at the most, 20 years. Great care should be used in the interpretation of these statistics. A simple division of unused supply by current production does not give an exact figure as to probable life, due to the fact that with increasing dearth and rising prices, oil not now economically recoverable will be brought to the surface, the supply of oil will be enlarged by more efficient methods in mining, and a relatively smaller volume of oil will be made to perform a given service through more efficient refining and application. Moreover, these calculations include only the known reserves, while as a matter of fact new fields have been discovered year by year which tend to offset the depletion of the proved territory, so that up to the present time the probable date of petroleum scarcity has been continually advanced.

Without question, however, in the future the world supply of crude oil must be obtained in larger part from countries other than the United States. Production in the Appalachian field, our oldest source, has been slowly declining for several years, and the same is true in the Lima-Indiana and the Illinois territory. The Mid-Continent flow is probably at its best, while the Gulf output of heavy crude has shown a decided increase recently. In the Rocky Mountain territory oil was first discovered in Colorado in 1876, but the volume was insignificant until the bringing in of the Salt Creek pool in Wyoming, which is now the leading State in the group, and many experts believe that this field is still in its youth and susceptible of great development. The declining tendency of production invariably displayed by a single well or group of wells, is illustrated by the record of the California field, our largest producer. In 1923 the flow from its three great pools in the Los Angeles basin, namely, Long Beach, Huntington Beach and Santa Fe Springs, disturbed the oil markets of the world, but since then has been declining and present production is around 300,000 bbl. daily from Southern California, compared with a peak of 663,000 bbl. reached in August, 1923.

A few years ago the United States Geological Survey prepared an estimate of the petroleum resources of the world and while it does not claim exactitude it furnishes an index of where we must look for our petroleum supply. Since the table was compiled the reserve in the United States has been drawn upon to the extent of approximately 2,000,000,000 bbl., and a number of new pools have been discovered that were not included in this estimate.

The important question is not so much where the reserves are located as who controls them. Although the American oil industry has up to the present time been supreme in the world marketing of refined products it has been somewhat behind its foreign competitors in the acquisition of new lands abroad. One reason for this is that certain foreign governments have held a particularly sympathetic attitude toward the oil industry in their respective countries and have aided and protected it in acquiring concessions, leases and other rights. Another reason is that American capital was not inclined to venture into foreign fields to any large extent until the last 10 years, with the result that British, Dutch and other European investors have acquired much of the desirable territory. The foreign fields being developed at the present time and showing the greatest promise include Russia, Persia, Rumania and Venezuela.—G. E. Roberts, National City Bank of New York.

Finish Failures Overcome with Pyroxylin Enamel

By H. C. Mougey[1]

Indiana Section Paper *Illustrated with* Photographs and Drawings

ABSTRACT

PUBLIC demand for more durability in automobile finishes has led to new developments in finishing materials and methods through cooperation of finishing materials manufacturers and automobile builders. By experimentation it has been found that certain cellulose nitrate materials, when applied over suitable under coats, dry quickly in the air by evaporation of the solvents and leave a film that is hard and tough. Its durability is many times greater than that of the most durable finishing varnish and, as it has been discovered that sufficient luster can be produced by rubbing and polishing the unprotected cellulose nitrate surface, one of the large automobile production plants adopted, in July, 1923, as its standard method of finishing, the use of such a finishing coat over primer and surfacer coats, obtaining the luster by polishing the cellulose nitrate top coat. A number of companies have now adopted this process.

Certain finishing material companies having discovered how to increase the quantity of cellulose nitrate in solution without increasing the viscosity, made possible its use for automobile finishing.

The change from a varnish to a pyroxylin finishing-system seems simple but a cellulose-nitrate finishing-material is complex. A large number of gums and oils can be used to obtain the desired properties but considerable study is required to determine the kinds and the quantities to use. The softeners and the stabilizers may be part of the solvents but they have their own duties to perform. The solvents hold the cellulose nitrate in solution and their evaporation permits the film to be deposited and harden. The nature of the solvents greatly influences the character of the film. Not all pyroxylin materials have great durability. This is obtained only by using the proper basic materials, combined in the right proportion and applied in the correct way.

The fundamental cause of the failure of finishes is the contraction of the top material while the underlying material is still moist. During exposure to rain or other dampness out of doors, the entire film absorbs moisture, swells and softens. When the sun comes out, the outer surface dries and contracts and, if the material is not sufficiently elastic to withstand the stresses, cracks develop. Durability can be increased by reducing the severity of these factors. By nature, the pyroxylin film is much less absorbent than the varnish film and the particles of pigment shade the materials beneath so that only the extreme outer surface is exposed to the sunlight. In time, the moisture and sunlight do, however, cause a type of failure known as "chalking." This effect is of such microscopic depth that it can be removed easily by washing with a mild abrasive or by polishing, thereby exposing a fresh surface, and in the case of a good cellulose-nitrate finish the washing or polishing can be repeated many times before any serious wearing away of the surface occurs. By mild polishing every few weeks, together with ordinary cleaning of the car, the finish can be kept with an appearance as good as it had on the showroom floor.

The author describes the fundamental operations in finishing an automobile body with paints and varnishes, explaining the purposes of the different coatings and the filling and rubbing, and classifies the successive coatings in all finishing systems as (*a*) primer, (*b*) surfacer, (*c*) color and rubbing and (*d*) finishing. To determine the cause of the rapid failure of finishes, test panels were exposed to the weather during different periods of the year and it was found that the length of life of varnishes depends greatly upon the season, varying with the amount of sunlight and heat, being shortest in summer and longest in winter. These tests also showed that the primer and surfacer coats were very durable but that the color and rubbing varnishes were of low durability, failing in from 1 to 5 weeks when unprotected by finishing varnish.

The real reason for the short life of the ordinary automobile finish was discovered to be the failure of the color and rubbing varnishes, which crack and take the finishing varnish with them. However, the finishing varnish is itself partially responsible for the failure of the color and the rubbing coats, because its film is easily scratched by grit and cleaning or by other mechanical injury, and failure of the underlying coat starts at these unprotected spots. The life of a varnish surface is shortened by regular polishing even if it is washed regularly only with water. A polish that is as nearly harmless as any is made of linseed oil mixed with enough turpentine to prevent the application of too heavy a film of oil. The life of ordinary production varnish-finishes can be doubled or quadrupled by the use of color and rubbing varnishes of high durability but they require a long time for air-drying and forced drying is likely to injure the color.

AN investigation was begun several years ago by the General Motors research laboratory with the object of securing more durable automobile finishes. In a preliminary study of the work of painting and finishing, as carried on at the several automobile plants, it was found that they all followed different practises and that the differences in the kinds of material used, the number of coats applied and the methods employed were great. However, the fundamental operations are simple and all the methods in ordinary use can be classified according to the properties desired in a finish.

A satisfactory finishing system must produce, at the least expenditure of labor, time and money, a finish that will (*a*) adhere to the automobile, (*b*) have a smooth surface of the proper color, (*c*) be of the desired luster and (*d*) retain these properties as long as possible. If the steel and the surface obtained by applying the coating are both smooth, light striking the surface will be reflected largely in parallel rays, producing an appearance commonly known as gloss or luster. This effect is indicated at the upper left in Fig. 1, in which the top

[1] M.S.A.E.—Control chemist, General Motors Research Corporation, Dayton, Ohio.

drawing at the right represents the cross-section of a piece of uncoated steel, while that just below represents the steel with a coating of finishing material applied. This coating is represented as being transparent, but luster does not depend on the use of a transparent coating; for example, although a common mirror is made by applying the reflecting coating of silver to the back of the glass, the high-grade mirrors used in optical instruments are made by applying silver to the front of the glass or by highly polishing metal, such as stellite or speculum metal.

The coating applied over the steel section in the third drawing from the top in Fig. 1 is represented as containing particles of colored powder, commonly known as pigment, which gives the color to ordinary paint. Minute particles of the powder lying close to the top of the coating produce an uneven surface that reflects the light rays in different directions, as indicated at the lower left, and it is this scattered reflection that produces the dull or semi-gloss finish, the degree of dullness depending on the amount of scattering of the light rays.

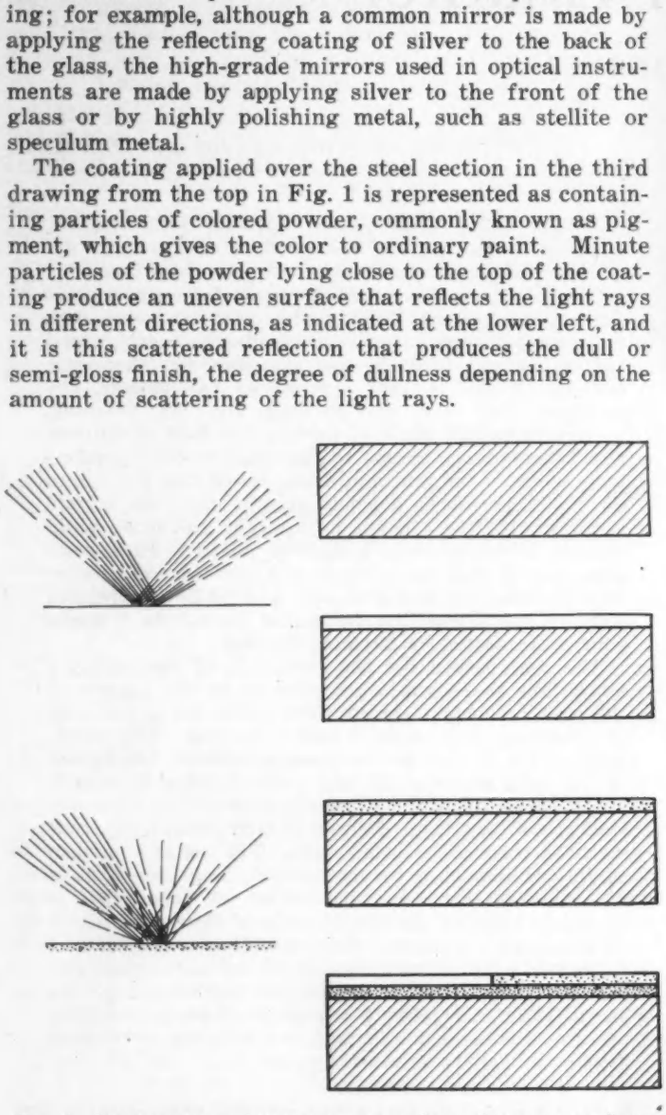

FIG. 1—DIAGRAMMATIC ILLUSTRATION OF CROSS-SECTIONS OF STEEL AND FINISHES AND THEIR EFFECT ON LIGHT

The Smooth Surface of the Plain Steel at the Top Right and of the Same Steel Covered with a Transparent Film, Just Beneath, Reflects Light in One Direction in Parallel Lines, as Indicated at the Top Left. Steel Covered with a Pigmented Coating, as in the Third Drawing from the Top, Does Not Have a Perfectly Smooth Surface and Scatters the Rays, Producing a Dull Effect. The Diagram at the Bottom Represents the Steel with Additional Coats of Finishing Material, the Half at the Right Containing Pigment that Gives a More Solid Color and Hides the Surface Better, While the Half at the Left Is Transparent and Gives a Colored Finish of Higher Luster

In the diagram at the bottom, the steel is shown as having additional coats of finishing material applied, the second coat at the right containing pigment and that at the left being transparent. The additional pigmented coat gives a more solid color and hides the surface better, while the smooth surface of the transparent coat over the first pigmented coat gives a colored finish of higher luster.

Black baking-enamel, such as is used on fenders, is simply a varnish made from certain black gums to which it owes its color. It does not ordinarily contain pigment of any kind and has a high luster when the finish is new.

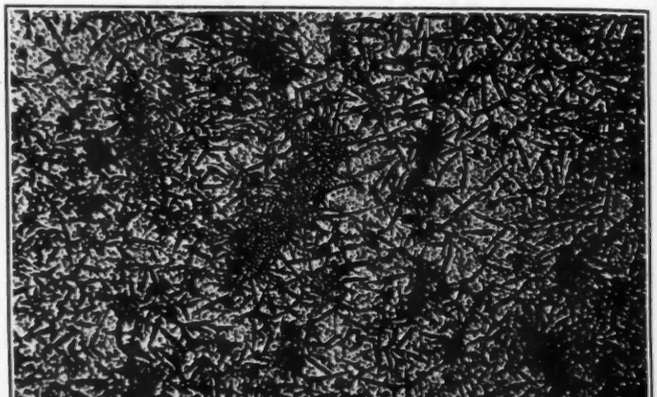

FIG. 2—MINUTE SURFACE CRACKS THAT DULL THE FINISH

These Are Only on the Extreme Surface and Can Be Removed by Polishing, Which Exposes a Fresh Surface

This luster gradually becomes dull in service and when the finish is examined under a high-power microscope it is seen that the loss of luster is due to microscopic surface cracks that cross and recross, as shown in Fig. 2, producing a dull surface similar to that of ground glass. These cracks are only on the extreme surface and, by polishing, this cracked surface can be removed and a fresh surface exposed, as in Fig. 3. This new surface is then subject to the same cycle of change. Unfortunately, the cracks that develop in the finish produced by the ordinary color-rubbing and finishing-varnish method are large and deep, as shown in Fig. 4, and the luster cannot be restored by polishing.

THE USUAL FINISHING PROCESS AND COATS

In Fig. 1 the steel is represented in the drawings as being very smooth, so that only one or two coats of finishing material were required to produce a good finish of the proper color and luster, but the surface of the steel used as ordinary automobile body stock is not perfectly smooth and the roughness of the original metal is augmented by the marks of files and other tools and there are also relatively large areas of high or low surfaces. A

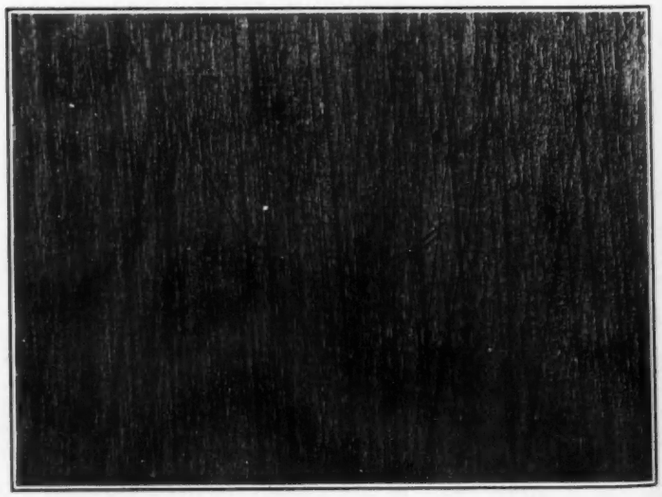

FIG. 3—FRESH SURFACE EXPOSED BY POLISHING A CRACKED SURFACE

This New Surface Also Becomes Cracked in Time and the Polishing Has To Be Repeated

cross-section of a piece of steel with such an uneven surface, greatly magnified, is shown diagrammatically in Fig. 5, with successive coats of finishing material. The first coat applied follows in general the irregularities of the steel surface, as shown in the top drawing, but by applying several additional coats of surfacing material, a coating is built up that is higher in its lowest spot than the highest peak of the metal. A smooth surface is then obtained by rubbing off the excess material. Pigmented coats are next applied, as indicated in the middle drawing, to obtain the desired color, and this layer is rubbed to produce a smooth surface. For this reason, the material in this coat is frequently called a rubbing varnish. To protect the rubbing-varnish coat and secure a high luster, a transparent coat of finishing varnish is finally applied, as shown in the bottom drawing, Fig. 5. Thus it is seen that all finishing materials can be classified as (*a*) primer, (*b*) surfacer, (*c*) color and rubbing, and (*d*) finishing. The number of coats applied depends upon the

FIG. 4—LARGE DEEP CRACKS IN ORDINARY FINISH
These Develop in the Finish Produced by the Ordinary Color-Rubbing and Finishing-Varnish Method and the Luster Cannot Be Restored by Polishing

smoothness of the metal and the degree of luster required.

SUNSHINE AND HEAT CAUSE RAPID FAILURE

Even though these finishes may be made of the highest-priced materials and applied with the utmost care, it is well known that the varnish finishes on automobiles in service do not retain their showroom appearance for long. Different explanations for the low durability of the finishes were made by manufacturers of the different coatings when we began our investigation. Those who made under coats blamed the top coats; the top-coat makers blamed the under coats, and those who furnished a complete line blamed the methods of application and drying. Therefore, to determine at first hand the real causes of the short life of automobile finishes, a great number of test panels were prepared in lap coats, as represented in plan and enlarged cross-section in Fig. 6, a portion of each coat being left uncovered in applying the succeeding coats so that the durability of each might be observed. These test panels were then exposed to the sun and weather in racks on the roof of the laboratory, as shown in Fig. 7.

It will be noted by the chart reproduced in Fig. 8, which shows the relation of the dates of exposure of the panels to their total life, that the durability of varnishes

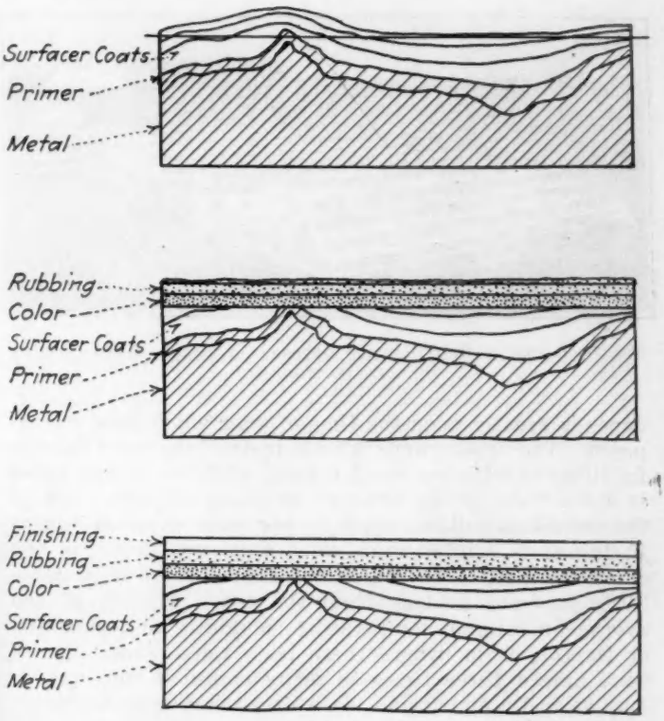

FIG. 5—DIAGRAMMATIC ILLUSTRATION OF USUAL FINISHING METHOD
Ordinary Body-Stock Steel Has a Rough Surface with High and Low Spots, as Indicated in the Greatly Enlarged Cross-Sections. The Primer Coat of Finishing Material Follows the General Contour of the Surface. Successive Surfacer Coats Fill the Low Places and Build-Up a Coating Higher than the Highest Peak of the Metal. The Excess Material Is Then Rubbed Off and Pigmented or Color Coats Are Applied, as Indicated in the Middle Drawing. These Are Rubbed to a Smooth Surface and Are Called Rubbing Varnishes. Finally, a Coat of Transparent Finishing-Varnish Is Applied To Protect the Rubbing Varnish Coat and Produce a High Luster

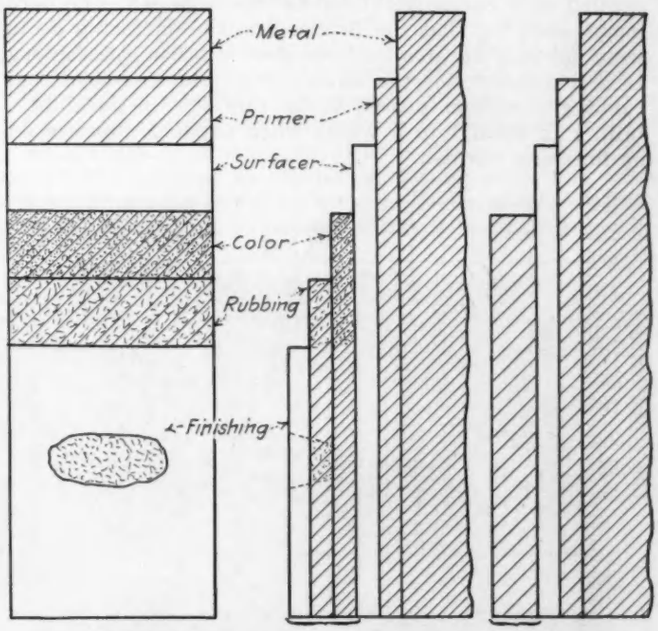

FIG. 6—PLAN AND CROSS-SECTION DIAGRAMS OF TEST PANELS
A Great Number of These Were Prepared for Exposure to the Weather To Test the Durability of the Various Coating-Materials. A Part of Each Coat Was Left Uncovered by the Succeeding Coat. The Drawings at the Left and in the Center Represent the Customary Finishing Method, in Which a Coat of Finishing Varnish Is Applied Over the Color and the Rubbing Coats. The Bracket at the Bottom of the Drawing at the Right Indicates a Combination of the Color, Rubbing and Finishing Coats in a Single Coating of Pyroxylin Enamel. This Enamel Produces a Film That Is Very Hard, Takes a High Luster with Polishing, Does Not Absorb Moisture and Is Sufficiently Elastic Not To Crack Under the Action of Direct Sunlight

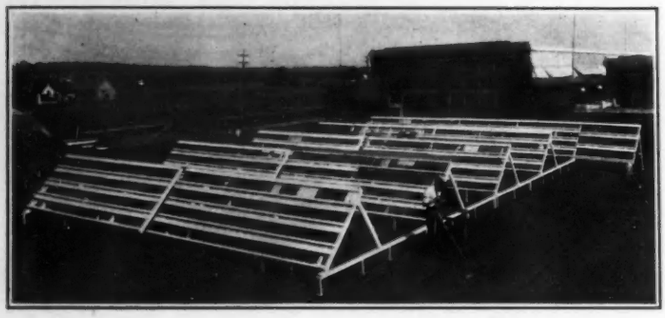

FIG. 7—RACKS OF TEST PANELS EXPOSED ON THE LABORATORY ROOF IN DAYTON, OHIO

depends greatly upon the time of year when they are exposed. The upper curve is from tests of the most durable finishing-varnish we could obtain, while the lower curve is from tests of an average finishing-varnish. All of the varnishes will last much longer when exposure begins in the early winter than when exposure starts in the early summer. The reason for this difference in durability becomes evident from the chart, Fig. 9, of the average maximum temperature, humidity and sunshine at Dayton, Ohio, where these tests were made. There were almost three times as many hours of sunshine in July as in December and the average maximum-temperature varied correspondingly.

CRACKING STARTS IN COLOR AND RUBBING COATS AT SCRATCHES IN FINISHING VARNISH

As a result of these panel tests, it was found that the primer and the surfacing coats were very durable even when unprotected by additional coats, and that the color, rubbing and finishing coats had the same durability when applied over surfacing coats as when applied over bare metal, showing that the primer and the surfacing coats were not only durable in themselves but also satisfactory as a foundation for the other coats. But the color and rubbing varnishes proved to be very low in durability, failing in from 1 to 5 weeks when exposed unprotected by finishing varnish.

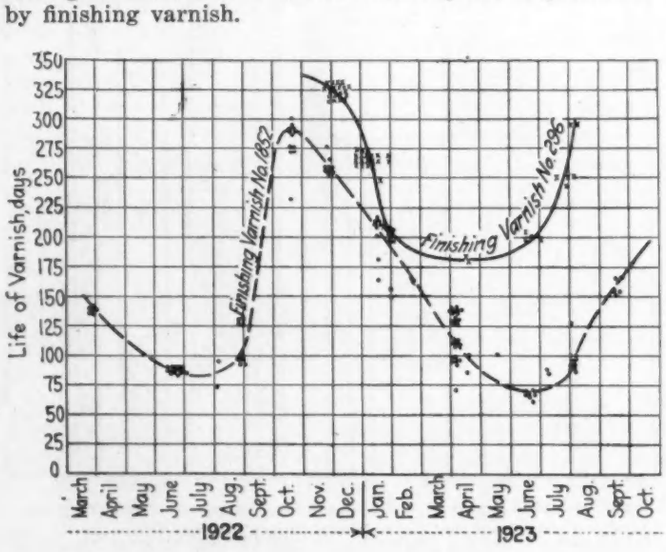

FIG. 8—RELATION BETWEEN LIFE OF VARNISHES AND SEASON OF EXPOSURE

The Upper Curve Is from Tests of the Most Durable Varnish Obtainable. The Lower One Is from Tests of an Average Finishing-Varnish. Both Were Applied Over Different Under Coats, All of Which Proved To Be Durable. Varnishes Exposed Beginning in October, December and January Showed a Length of Life of from 200 to 325 Days, While Those Exposed Beginning in April, June and August Failed in from 70 to 300 Days

The finishing varnish is supposed to protect the color and rubbing varnishes of low durability but the task is too great and the real reason for the short life of the ordinary automobile finish is the failure of the color and the rubbing varnishes, which crack and take the finishing varnish along with them. On the other hand, it is apparent that if a finishing varnish that is applied over color and rubbing varnish of low durability is removed in spots by grit and cleaning of the car or any other mechanical injury, thereby leaving the color and the rubbing varnishes unprotected, failure will start at these places. This actually happens in service, as shown in the photographs reproduced in Fig. 10, which show, from left to right, the progressive failure of an automobile finish, starting at the scratches where the protection of the finishing varnish is removed. The fact that a finishing-varnish film is so easily scratched is one of the main causes of the early failure of paint and varnish finishes.

Numerous polishes are on the market for which the claim is made that they not only improve the appearance of the finish but actually increase the life of the varnish film by acting as a protective coating, as a "varnish food" or as a "seal" that closes the pores of the varnish film and makes it more resistant to weather. We have made a large number of tests with different commercial polishes of many types but have always found that the life of a varnish surface that is regularly polished is shortened. The varnish film is mechanically injured by any of these treatments and fails prematurely. A polish that we have found to be as nearly harmless to the varnish as any is a mixture of linseed oil with enough turpentine to prevent the application of too heavy a film of the linseed oil. The regular use of a suitable polish is very desirable, however, we believe, on a black baking-enamel finish or any other finish that is hard enough to resist the effect of the polish, such as cellulose-nitrate materials.

PYROXYLIN AIR-DRIES QUICKLY, LEAVING A HARD, TOUGH, DURABLE FILM

Tests have shown that if color and rubbing varnishes of high durability are used an increase of from two to four times the life of ordinary production finishes can be obtained. This fact is now being advertised by one of the largest varnish manufacturers and has been made use of during the last 2 years by manufacturers of some of the high-priced automobiles. The durable color and rubbing varnishes, however, require a long time for air-drying and if an attempt is made to shorten this time by forced drying the danger of injuring the color is great. For these reasons, a material that will air-dry quickly, can be rubbed to a smooth finish and is very durable, is desired. It has been found that certain cellulose-nitrate materials possess these qualities, the evaporation of the solvents, when these materials are applied over suitable under coats, leaving a film that is hard, tough and very durable. The cellulose-nitrate finishes harden in a remarkably short time, as they dry by evaporation of the solvents instead of by chemical change of the materials left after evaporation of the solvents, as ordinary varnishes do.

When cellulose-nitrate materials were first applied to cars in production plants, they were used only to replace the color and the rubbing varnishes. They were applied over surfacing coats and the luster was produced by the use of a finishing varnish as a top coat. As the durability of such a finish is limited by the relatively low durability of finishing varnishes and as it was found that sufficient luster could be produced by rubbing and

polishing the cellulose-nitrate materials, which, although unprotected, have a durability many times greater than that of the most durable finishing-varnish, one of the large automobile production plants adopted, in July, 1923, as its standard method of finishing, the use of a cellulose-nitrate material applied over primer and surfacer coats, obtaining the luster by polishing the cellulose top coat. Since that time this same method of finishing has been adopted by a number of other companies. This method is illustrated in the diagram at the right in Fig. 6, in which the bracket at the bottom indicates the top coat of cellulose-nitrate material that takes the place of color, rubbing and finishing coats embraced by the bracket in the middle drawing.

Complexity of Cellulose-Nitrate Finish

The change from a varnish system to a pyroxylin or cellulose-nitrate system would appear to be very simple but in reality it involves a number of important factors. This is due, in part, to the fact that a cellulose-nitrate finishing material is very complex, consisting in general of (*a*) cellulose nitrate, (*b*) gums, (*c*) oils, (*d*) softeners, (*e*) stabilizers, (*f*) solvents and (*g*) pigments.

The cellulose-nitrate formerly used in making pyroxylin finishes had one very serious fault; only very small quantities could be put into solution without the mixture becoming so thick that it could not be applied and such a great number of coatings of the thin mixture was required to build-up a film to produce the solid color desired as to make the process impractical. However, certain companies have recently discovered how to put several times the former quantity of cellulose-nitrate in solution without increasing the viscosity of the solution beyond that of the old-type solutions. The possibility of the use of cellulose-nitrate enamels for finishing automobiles dates from this discovery.

A large number of gums and oils can be incorporated in a pyroxylin material to obtain desired properties but considerable study is required to determine the kinds and amounts of these materials to use. The softeners and stabilizers may be part of the solvents also but they have their own duties to perform aside from that of any solvent action. The solvents hold the cellulose-nitrate in solution and by evaporation permit the film to be deposited. The character of the film is greatly influenced by the nature of the solvents. The pigments are the colored powders to which the finishes owe their color.

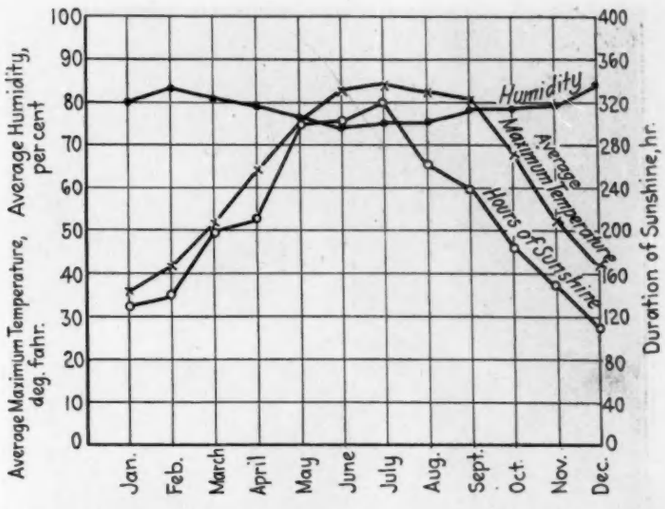

Fig. 9—Monthly Variation of Hours of Sunshine, Maximum Temperature and Humidity at Dayton

Comparison of This Chart with Fig. 8 Shows That, as the Hours of Sunshine and the Average Maximum-Temperature Increase, the Life of Varnish-Finishes Decreases, the Finishes Exposed in Autumn and Early Winter Lasting Longest, While Those Whose Exposure Starts in Spring and Early Summer Have the Shortest Life

Fundamental Causes of Finish Failure

The question frequently arises, To what do pyroxylin finishes owe their great durability? Unfortunately, all pyroxylin materials do not have great durability; only by using the proper basic materials, combining them in the right proportions and applying the mixture in the right way is it possible to obtain great durability.

The fundamental cause of failure of finishes is simple and is a matter of common observation. In the baking of sugar cookies, the tops of the cookies harden first and as the baking continues the relative areas of the tops and the materials underneath change, thus resulting in the forces that cause the surfaces to crack. This relative change may be brought about by either expansion of the lower materials or contraction of the top materials. The familiar cracks in mud along the river banks, as illustrated in Fig. 11, are examples of cracks caused by con-

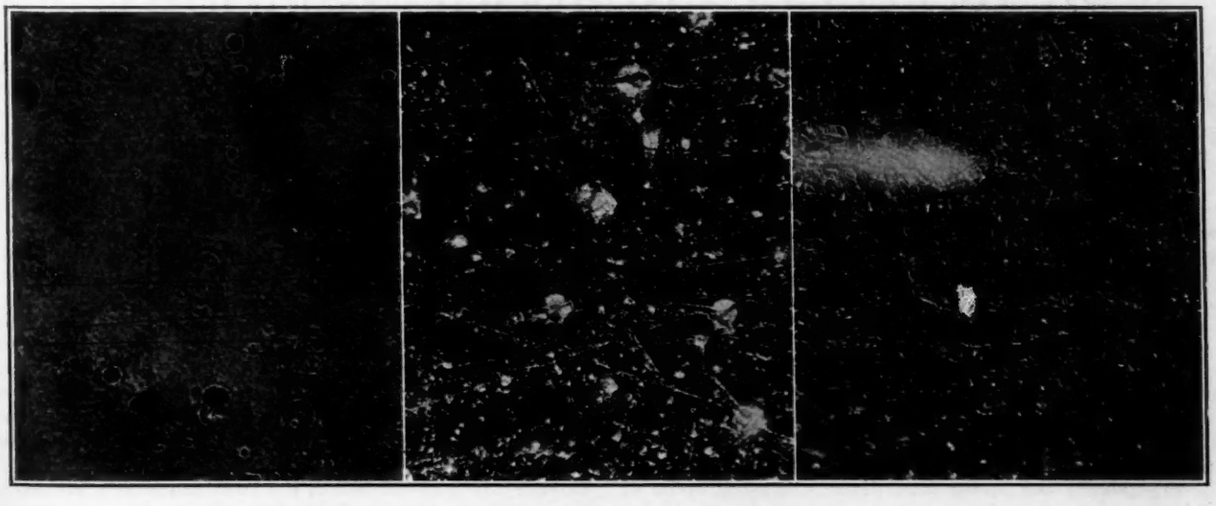

Fig. 10—Progressive Failure of an Automobile Finish Starting at Surface Cracks and Other Injuries

From Left to Right the Photographs Show the Cracking of Under Coats Beginning at Surface Injuries and Developing into Deep Broad Cracks with the Surface Film Half Gone. The Fact That the Finishing Varnish Is Easily Scratched Is One of the Main Causes of the Early Failure of Paint and Varnish Finishes

FIG. 11—CRACKS IN THE MUDDY BANK OF A STREAM
These Illustrate the Fundamental Cause of Failure of Automobile Finishes. Drying-Out and Contraction of the Surface While the Underlying Material Is Wet and Swollen and Is Too Weak To Resist the Surface Stresses Allows the Top To Crack. Varnishes Absorb Moisture Readily and Become Soft and Swollen. Exposure to the Sunlight Quickly Dries-Out and Contracts the Surface Varnish and the Coats Beneath Are Not Elastic Enough To Prevent Cracking

traction of the top materials. A contributing cause in this case is the soft under-material of low strength. The mud at the top shrinks as it dries and since the soft mud beneath is too weak to hold the top material in place by adhesion, the shrinkage develops cracks.

Similarly, the cracking of varnish finishes may be caused by the drying and the contraction of the top coats over insufficiently dried under coats. Moreover, when exposed out of doors, the entire film absorbs moisture from rain, mist or dew and swells and softens. Then, when the sun comes out, the top coat dries and contracts and if the material is not sufficiently elastic to withstand the stresses, cracks develop. It is a matter of common knowledge that finishes fail much more quickly during outside exposure than indoors. If pianos were parked at curbs and automobiles always stood in houses, the respective durability of their finishes would be reversed. Moisture and direct sunlight are the principal causes of the severity of outside exposure and the durability of finishes can be increased by reducing the severity of these factors. By nature, the pyroxylin film is much less absorbent of moisture than is the varnish film, and the particles of pigment, which are used primarily for their color, also shade the materials underneath them so that only the extreme outer surface of the finish is exposed to sunlight. Thus, the effects of both moisture and sunlight are reduced.

These factors do, however, act on the surface and in time cause a type of failure known as "chalking." This occurs only on the extreme surface and can be removed easily by washing with water and a mild abrasive or by polishing, thereby exposing a fresh surface. The new surface then goes through the same cycle of change, as in the case of black enamel, but, as this failure is of microscopic depth in the case of good cellulose-nitrate finishes, the cycle of change may be repeated many times before any serious wearing away of the outer film results. By slight polishing every few weeks, together with the ordinary cleaning of the car, the finish can be kept with an appearance as good as, and in some cases even better than, it had in the showroom.

The new developments in automobile-finishing materials and methods have resulted from the demand of the public for cars having more durable finishes than heretofore and from the cooperation of the manufacturers of finishing materials and the carbuilding companies. It is believed that, because of the work that has been done and is still being done, the life of automobile finishes will be lengthened considerably.

GLASSES AS UNDERCOOLED LIQUIDS

THE view that glasses are undercooled liquids was advocated by Tammann 30 years ago and is, of course, widely held now. Glass is in a condition intermediate between the solid and liquid states. At ordinary temperature that condition may, as Tool and Hill, of the Bureau of Standards, put it, be regarded as undercooled with respect not only to the crystallization or true solidification but also to many processes normal to the vitreous condition. When a crystal is heated, it begins in general to melt at a definite temperature; only crystals that form very slowly can be superheated. But on cooling most crystals behave differently. The melt can be undercooled before crystallization will begin, and the crystallization may set in at certain centers, or crystals may grow in all directions from one center as in a spherulite. Crystallization and the capacity for undercooling depend, according to Tammann, upon the number of crystallization centers or nucleus number formed in unit volume per unit of time, and upon the linear rate of growth of the crystals in the undercooled liquid. Fusing some of his substances in sealed glass tubes, he found that, for easily fusible substances the maximum nucleus-number was attained after undercooling by about 100 deg. cent. (180 deg. fahr.), and that in other cases no centers whatever originated even with strong undercooling. The rate of growth of the crystals increased with the degree of cooling and with the ease with which the latent heat of crystallization could escape; for a crystal growth of about 4 mm. (0.157 in.) per min. the rate of crystallization had its maximum when the undercooling amounted to about 20 deg. cent. (36 deg. fahr.). At first the viscosity changes very little with undercooling. Most liquids, except fused silica, acid aluminum silicates and arsenic acid, remain mobile until undercooled by about 90 deg. cent. (162 deg. fahr.); then the viscosity increases rapidly, and when undercooled by 110 deg. cent. (198 deg. fahr.) glasses turn hard and brittle. Vitreous substances have no definite melting-point, and no distinct absorption of heat occurs during their gradual softening. To obtain a good amorphous glass, the rate of undercooling should be especially rapid in the undercooling range of 30 to 100 deg. cent. (54 to 180 deg. fahr.). The smaller the mass of liquid, the more rapidly it will turn into a glass by sudden cooling, since the nucleus number is appreciably much smaller in a volume that is reduced proportionately.—*Engineering* (London).

Bearing of Research Department Work on Car Developments

By H. L. Horning[1]

Chicago Section Paper

ABSTRACT

IMPROVEMENTS in automobiles seen at the 1925 shows reflected research work instigated by the Research Department of the Society. Investigations to determine the economics of fuel possible to use satisfactorily in present carbureters and engines and producible in largest quantities from crude oil resulted not only in finding that present motor fuels are good but also in determining that bad results from their use arise from heavy fuels or dilution of the engine lubricant. Several new car models are provided with oil-cleaners, some with air-cleaners and others with hot-spot manifolds for the respective purposes of removing impurities from oil as it is used, of preventing the entrance of dust with the air and of vaporizing the fuel more thoroughly before it enters the cylinders, particularly at low loads. Great improvement in design has also been made to produce better combustion, some engineers attacking the problem through the carbureter, some through the manifold and others through the location of the spark-plug.

Proper lubrication is one of the outstanding problems. Research work showed that we have been lubricating the engine with mud, that is, a mixture of oil and miscellaneous matter, and it is a marvel that the engine runs and wears as long as it does. The author predicts wide adoption in the next year or two of means of cleaning the oil as it is being used or of feeding fresh oil directly to the cylinder-wall, and cites the remarkable performance during the war of the Albion engine, in which such a system is used to get fresh oil to the walls and top piston-rings. A new era of easy chassis lubrication has been inaugurated, with systems in two makes of cars by which all points on the chassis are greased or oiled from a central reservoir by a push on a foot plunger or a pull of a pump handle.

Advent of the balloon tire started investigation of riding-qualities. Vibration causes the greatest annoyance in a car and tests at the Bureau of Standards show that slight vertical or lateral vibrations can be very disagreeable and cause fatigue by the constant repetition of impulses sent to the brain. It was observed at the shows that engineers are paying much attention to ways of mounting the engine in the chassis so that the engine vibrations are isolated.

Nitrocellulose finishes are being used extensively and prove a great help to production and in the practical use of cars. The end of their development has not been reached.

The activities of the Research Department of the Society are analyzed as consisting of serious forward-looking research work in anticipation of problems to be met in the next few years and of "bread-and-butter" assistance to members in solving their day-to-day troubles. As an example of the practical assistance the Department renders to members, Mr. Horning narrates trouble he had with a vibrating flat surface on a crankcase and how, in response to a telegram, he received in 2 days from the Research Department data on an investigation made in 1802 that solved his problem. The work was aided by the knowledge of the Chaldni investigation of designs formed in sand on a vibrating plate. The sentiment of the Research Department is expressed by the statement that it hopes the many letters of inquiry received monthly will increase, as the purpose of the Society is to bring to light the developing knowledge of the forces of Nature and to disseminate this knowledge among the members.

THE Research Department of the Society has, throughout its existence, been promoting a test of fuels with the object of determining the most economical fuel that would act well in our present carbureters and engines and still permit the greatest yield of gasoline from a barrel of crude oil. We have practically determined that and it is very gratifying to be able to present the result to the commission now investigating the conservation of our petroleum resources. A number of by-products of that investigation are very valuable, such as the effect of oil dilution on the wear of cylinders and the seriousness of dilution in its relation to the fuel problem. We found that present fuels are rather good and that the only bad results from their use were those arising from heavy fuels and from dilution of the lubricating oil.

Methods of Keeping Oil Clean

I will not say that the development is arising out of the activities of the Research Department, although I do not doubt that it has been influenced by that, but at the shows we have seen oil-cleaning devices such as the Skinner in use on the Rickenbacker and the modified form on the new Packard car. The purpose of the device is to reduce the dilution. It shows one of the results of research and calls attention to the evil of dilution and the effort that is being made to correct it.

Other engineers are dealing with the dilution problem by more thorough vaporization of the fuel mixture, and certainly it is gratifying that, following the report of the Fuel Committee on hot-spot manifolds 4 or 5 years ago, the hot-spot manifold or some modified type of it is now almost universal on all internal-combustion engines. One of the most significant designs is that used on some of the General Motors cars in which they try to give a very hot mixture at low loads and a much cooler mixture at full load. That is not entirely possible with a hot-spot manifold but they do it by several expedients and it is a very good thing. Some development has been made recently in the direction of feeding a cold mixture at full load and an exceedingly hot mixture at no load and the system has been found to give remarkable acceleration on the road.

As you know, more attention has been given in the last 10 years to combustion in the cylinders and combustion heads and to increasing the compression of engines, because it is known better how to cool the hot-spots, such as the exhaust-valves and the bosses around the spark-plugs, and to what is the best location for the spark-plugs. In the majority of cases, as revealed at the show, great improvement has been made in the de-

[1] M.S.A.E.—President, Waukesha Motor Co., Waukesha, Wis.

sign of engines especially as relating to combustion. Some engineers attacked the problem through the carbureter, some through the manifold, some through the location of the spark-plugs and some by other means. A consistent serious effort has been made by designers to make the engine more efficient.

Lubricating Engines With Mud

One of the outstanding problems is lubrication. We have learned from the research work that we have been trying to lubricate with mud. When you analyze the lubricating oil from the cylinder-wall, it is remarkable that our engines have run so long and that the cylinders wear so well. You have the dilution of the oil by the products of combustion and of partial combustion, the wearings from the cylinder-wall, carbon and gasoline or kerosene. It is that dirty mixture which is used for lubricating the top piston-ring. Not long ago I received a letter from a man who recently became closely connected with the Society in which he stated that his company had made a long investigation of the qualities of iron and that he could not find any consistent relation between good iron and bad iron and pistons of one kind and another kind of iron. He inquired what we knew about it. I replied that we did not know anything about iron but did know that engines could not be lubricated with mud and that when the cylinder was lubricated with oil it did not make much difference what kind of iron was used for the cylinders and pistons, so long as the two irons were kept apart.

That means two things: one is that the oil can be cleaned, as is done on the Chrysler car with the new system in which the oil stream is divided and one part is filtered while the other is being used. Eventually, all of the oil becomes clean even if it starts dirty, but it never gets dirty with that system. I saw a filter taken out after a run of 500 miles and was shocked to see what the engine gathered up in that distance and what that device took out of the oil. After seeing that, it is unbelievable that an engine could run thousands of miles and not wear out the cylinders.

We shall see wide adoption in the next year or two, I think, of means for cleaning engine lubricating oil as it is being used, whether of the type mentioned or a method like that we are using on our own 100-hp. engine. We found that by direct lubrication of the cylinder with clean oil we could cool the pistons to such an extent that even a badly knocking engine ceased to knock and that the cylinders wore so well that we did not have any repair business, so we will adopt that or some other method of keeping the oil clean.

Clean Oil Means Long Life

When some means of putting clean oil on the bearing surfaces is adopted generally it will not be uncommon to go 125,000, 150,000 and 175,000 miles without adjusting a bearing. It is not impossible, it is not impracticable; it is absolutely probable. The Albion engine, made in England, has a crankshaft about 1½ in. in diameter. It was smaller in diameter, I think, than any other used in the war. The engine cylinder had a 4½-in. bore and the bearings wore throughout the war. The experience of the British army with those bearings was better than with any of the rest of the engines of many designs or with any oiling system. The only unusual feature about the engine was that fresh oil was fed to the cylinder-walls and the cylinders lasted so long that the pistons in some of them never were replaced during the war. The oiler used is very complicated; the result can be secured much more simply, but the accomplishments with that engine during the war are outstanding.

The Cleveland car, as you know, has the "one-shot" system of chassis lubrication. It is a good job and it looks to me to be very effective. You doubtless noticed the description[2] of the Bijur system of lubricating the entire chassis from one place and you will be pleased to know that is on the new Packard. Those two systems will inaugurate a new era, making it easy to lubricate the whole chassis.

Regarding engine lubrication and long engine life, I think you will see air-cleaners widely adopted in the next year. A thoroughly good air-cleaner can increase the life of an engine enormously.

Vibrations of 0.001 In. Are Tiresome

You could not go anywhere at the show without seeing balloon tires. They, of course, are associated with riding-comfort or riding-quality. When an investigation of agreeable riding by the Research Department was first proposed, somebody called it "riding-comfort." Balloon tires gave the impetus for making investigations of how to get riding-comfort but we had to change the term to "riding-qualities" so as not to hurt anyone's feelings. The subject of riding-qualities covers a multitude of sins.

At the 1925 Annual Meeting vibrations were discussed extensively because they are by far the greatest annoyance in a car and they cause most of the disagreeable riding-qualities, whether the vibration be the largest oscillation caused by the springs or the rapid vibration of the engine. The Society's Research Department is concluding an investigation of vibration at the Bureau of Standards. I will tell you one of the interesting recent developments and hope they will be able to tell you many at the Summer Meeting. The investigators at the Bureau have arranged a seat with a cushion for a man to sit on and this can be vibrated up and down and sidewise for a certain distance at a certain rate. You will be surprised to know that a vertical vibration of 0.001 in. can be disagreeable; it can be felt distinctly and one can be really wearied by it. They have also determined that a lateral vibration of 0.002 in. can be felt and be very disagreeable if repeated often enough.

In connection with this, I noticed at the show that the engineers were paying considerable attention to methods of attaching the engine to the chassis so that the chassis would not take-up the vibration of the engine. I think it can be said, in light of our present knowledge, that no excuse can be found for the engine communicating all of its vibration to the chassis; that it can be mounted so it will not do so and thereby save a considerable amount of wear and tear. It is the constant reception of vibration impressions by the brain that wears a rider out.

Our Chairman said that I looked below the finish of the cars at the show. I did, in most cases, but I could not avoid noticing the wide use of nitrocellulose finishes, and I certainly like them; they will prove a great help to us not only in production but in the practical use of our cars. I am glad to see them developing and do not think we have reached the end of that development.

One very interesting thing I noticed in a Cleveland car was a sort of cast pipe leading from the top of the engine to the radiator. It is cast exactly to design and has strengthening at the end where it slips over the connections. It looks like a "regular" manifold and has no kinks in it. I was pleased with the ingenuity it re-

[2] See THE JOURNAL, March, 1925, p. 335.

flected and thought it would be well for many of us to attempt something along the same line.

Research Department Undertaking Serious Work

We have analyzed the activities of the Research Department as being of two kinds; one is the serious research work which is forward-looking and has to do with problems that we are reasonably sure will come before us in the next few years. Some are intensely scientific and of interest, probably, to only 10 per cent of our members. We feel that it is necessary to have the highest type of man engaged in that work. On the other hand, we have the bread-and-butter end of the research work, which consists of furnishing information that we find necessary for carrying on your business from day to day. To illustrate, on March 10, at 10 a. m., I sent a telegram to the Research Department for information contained in a certain document that might be in the archives of the Engineering Societies Library. At 1 o'clock on the 12th the information was in my hands. I have done this several times and know that other members have. That same service is at your command. If you suddenly find that you need information of a research or commercial nature in any line of development, send a telegram or letter to the Research Department and you will be surprised to see how much you will get and how quickly you will receive it.

Problem Solved by Research of 1802

The most valuable reference in the letter of response to my telegram was an extract from a research development that was made in 1802, and I used it, too. We had a flat surface on the engine that was a regular loudspeaker for what was going on in the engine. I knew that a flat surface was wrong but we wanted a flat surface. So the Research Department investigated and found the rate of vibration of a flat surface is directly proportional to the thickness of the metal; if you double the thickness you will get a sound an octave higher; if you make it 50 per cent thicker the note will be *G* or *C*. All you have to do is take a hammer or tuning-fork and go around and strike the surfaces so they will not tell anything. On the end of the crankcase we had a place that when hit gave nearly the last *C* in the scale but did not give out a sound from the engine during operation. We added metal here and there and changed the rate of vibration and absolutely cured our trouble. It was the 1802 investigation that enabled us to do it.

We also learned that the rate of vibration varies inversely as the area of a given surface. Then there were the Chaldni[3] figures made in the investigation of symmetrical designs formed in sand on a vibrating plate. When the plate is struck and one corner is held with the fingers, a certain design running to a center is formed; when the plate is held in three places a different design is formed, and when it is held in four places a third design appears. The interesting fact about the surface that was giving us trouble was that, if you ran your finger along it toward the center, it would come to a spot the size of a dollar that you would swear was detached from the crankcase and was vibrating intensely. When we got metal placed correctly at that spot, the spot stopped dancing; it just happened to be in periods and was the one weak spot of that surface. As we went over the different surfaces we had the same problem but, taking advantage of the fact that the rate of vibration varies inversely as the area of the surface, we placed ribs here and there and the problem was solved.

That was a very practical application of the work of the Research Department; it is a day-in-and-day-out and dollars-and-cents thing. I can voice the sentiment of the Research Department in saying that we hope the many letters of inquiry that come in every month will increase. We are putting on men of ability to help solve your problems because the purpose of the Society is to bring to light the forces of Nature and disseminate the knowledge of those forces.

[3] See Ganot's Physics, p. 271; also THE JOURNAL, December, 1923, p. 448, and May, 1924, p. 547.

[4] M.S.A.E.—Member research council, Standard Oil Co. Research Laboratory, Whiting, Ind.

[5] M.S.A.E.—Consulting engineer; chief engineer, American Federal Wheel Co., Chicago.

THE DISCUSSION

CHAIRMAN R. E. WILSON[4]:—Mr. Horning has certainly touched on a very interesting service that our Society renders. We all know that the number of services is increasing every year and that the value of our membership is going up. I do not think anything is much more important than this research service, which I can testify is very efficient and helpful.

W. E. WILLIAMS[5]:—What Mr. Horning said about the impurities and the grinding material that gets into the lubricating oil is one of the most important things that has ever been brought out for the benefit of the industry. Not long ago I drew some oil out of a crankcase, thinking it was hardly good enough for an automobile that had run only about 200 miles and that I would use it to lubricate a machine I have, but on second thought I decided it would be a good grinding material if I wanted to grind out the bearings. I think purity of the oil is the greatest thing in sight for the life of our cars.

One other point occurs to me. A large quantity of household oil-burning apparatus has been developed that will burn what is called "gas oil," which is a close approach to kerosene and can be bought for a much lower price. It seems to me the tractor men should begin to look at that as a prospective fuel. I have an oil-burner that burns gas oil that costs 6½ cents a gal. as against a low-grade kerosene at 9, 10 and 11 cents. It burns this fuel just like gas. A tremendous quantity of that gas oil is produced, and it is produced cheapest during the summer when the tractor is most used and is at the highest price in winter when the oil-burner is used. I think a field exists for the development of the carbureter and the tractor engine to use that class of fuel. It will flow at a temperature below zero, it is claimed, at least most of it will unless too much paraffin is contained in it.

CHAIRMAN WILSON:—It might be worth suggesting that we first need to get tractors that will burn kerosene satisfactorily. I do not doubt that a few may be on the market but our experience is that a large proportion of users buy them to run on kerosene and after a few months' experience switch over to gasoline in spite of the price differential. Gas oil is not so close to kerosene as the uninitiated might assume. It probably has about one-fourth of the vapor pressure of kerosene, and kerosene certainly is hard enough to vaporize. It would be a fine thing from the standpoint of cost, but I doubt if a carbureting or Otto-cycle engine is the type to use it.

Factors Determining the Minimum Stopping-Distance of an Automobile

By H. H. ALLEN[1]

METROPOLITAN SECTION PAPER *Illustrated with* DIAGRAMS AND CHARTS

ABSTRACT

CLAIMS and counter-claims as to the deceleration possible under certain conditions, especially when applied to the legal questions arising at the time of an accident, induced the author to make an investigation of the subject. An attempt has been made to include all the variables that are of significance or of sufficient magnitude to affect appreciably the performance of a car under a given set of conditions of the vehicle or of the environment. Inasmuch as the calculations are simplified by doing so and because the difference between the amounts of deceleration and of power involved are small, the assumption is made that the maximum deceleration occurs when the wheels are locked, rather than when they are still rotating. The stopping-distances, theoretically obtained, apply to level-road conditions only.

Through a series of mathematical equations, based on the weight of the car, the proportion of the weight on the front and on the rear wheels, the height of the center of gravity above the road, the length of the wheelbase, the coefficient of friction between the tires and the road, the velocity and the like, conclusions are reached that:

(1) With two-wheel brakes, the transfer of effective weight from the rear to the front wheels is directly proportional to the rate of deceleration

(2) With four-wheel brakes, this effect can be neglected, for the retarding force exerted by the front wheels is increased by the same amount as that of the rear wheels is reduced

(3) The maximum deceleration is independent of the weight of the car and increases with the coefficient of friction between the tire and the road

(4) In cars with two-wheel brakes only, the maximum deceleration increases as the percentage of weight on the rear wheels increases, as the height of the center of gravity above the road becomes less and as the wheelbase becomes longer

(5) The extent to which the maximum deceleration of two-wheel-braked cars is affected by a change in the ratio of the height of the center of gravity above the road to the length of wheelbase is shown to be as the square of the rate of deceleration and in the opposite direction; that is, as the ratio becomes greater, the deceleration becomes less in proportion to the square of its rate

(6) Although the maximum deceleration in cars with four-wheel brakes is to be obtained when all four wheels are locked, better control is secured when the front wheels are rotating; consequently, most brakes are adjusted to this manner

[1] Automotive powerplants section, Bureau of Standards, City of Washington.

CONSIDERABLE attention has been brought to bear on the problem of automobile brakes and braking because of the claims and counter-claims that have been made concerning decelerations obtainable under certain conditions. It is not unusual to hear a person assert that his car can be stopped within certain sharply defined limits, whereas careful analysis shows that to do so a deceleration either physically impossible or extremely unlikely would be required. If an average driver is asked within what distance he can stop from a given speed, the answer is likely to be anywhere from one-quarter to one-half the minimum possible stopping distance.

This statement indicates that in the event of a person's being brought to trial because of an accident, a correct interpretation of the facts is not probable, if the effects of such variables as car speed, road traction and the like are not known or appreciated in their true proportion in relation to the performance of a car during, or immediately preceding, the application of the brakes.

Among the legal questions that may arise when an accident occurs are:

(1) Knowing the speed of the car prior to the application of the brakes, what is the minimum distance within which the car can be stopped?

(2) Knowing the distance within which a car has been stopped, what was its probable speed when the brakes were applied?

(3) Knowing the speed and the stopping-distance, what is the probability that the braking equipment was in good condition and was employed to the full extent of the operator's ability?

The answer to each of these questions depends upon the maximum deceleration possible and will differ both with the car dimensions and the brake equipment.

The following discussion is an attempt to summarize and to explain the derivation of some of the relations that are essential to a correct determination of possible deceleration. An attempt has been made to include all the variables that are of significance or of sufficient magnitude to affect appreciably the performance of a car under a given set of conditions of the vehicle or of the environment. It will be noted that all the equations and curves involving stopping-distances apply to level-road conditions only.

It will be assumed that the condition of maximum deceleration occurs when all the braking wheels are locked. This assumption simplifies the problem but must be justified, as it is generally, and correctly, believed that the maximum deceleration is obtained when the wheels are still rotating. Justification lies in the fact that experiments have shown that the difference between the maximum deceleration and that which is obtained with the wheels locked is small. Moreover, the difference between the force that must be applied to the brake-drums for maximum deceleration and that which will lock the wheels is so small that, as brakes are at present

constructed, little likelihood exists that the first condition will be attained and not the second.

The following nomenclature is used throughout the paper:

a = Deceleration, ft. per sec. per sec.
F = Total decelerating force, lb.
f = Coefficient of friction between tire and road.
g = Acceleration due to gravity = 32.2 ft. per sec. per sec.
h = Height of center of gravity of car above road, in.
L = Wheelbase of car, in.
$M = W/g$ = Mass of car
$p = W_a/(W_a + W_b) = W_a/W$ = Fraction of total weight of car on rear wheels
$R = H/L$ = Ratio of height of center of gravity to wheelbase
s = Stopping-distance, ft.
$V = 3600\ v/5280$ = Velocity, m.p.h.
v = Velocity, ft. per sec.
W = Weight of car, lb.
W_a = Actual weight on rear wheels, lb.
W_b = Actual weight on front wheels, lb.
$W_f = (W_b + W_s)$ = Effective weight on front wheels at any instant during deceleration, lb.
$W_r = (W_a - W_s)$ = Effective weight on rear wheels at any instant during deceleration, lb.
W_s = Effective weight shifted to front wheels during deceleration, lb.

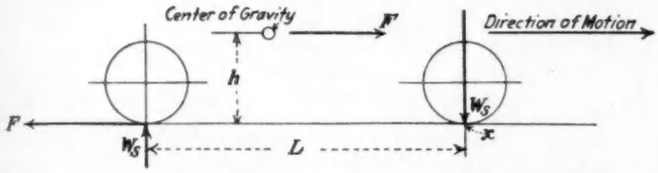

FIG. 1—DIAGRAMMATIC SKETCH SHOWING MOMENTS THAT RESULT FROM THE DECELERATION OF A CAR TRAVELING IN THE DIRECTION INDICATED BY THE ARROW
The Total Force of Deceleration Is Applied in the Plane of Contact between the Wheel and the Road

Fig. 1 shows the moments that result from the deceleration of a car traveling in the direction of the arrow. The total force of deceleration is applied in the plane of contact between the wheel and the road. Inasmuch as the center of gravity of the car is above this plane, a moment Fh is created tending to rotate the car in a vertical plane. This enters the problem of braking as an equivalent moment W_sL, tending to lift the rear wheels and to press the front wheels harder against the ground, thus tending to rotate the car about the point x. The effect upon braking is the same as if the weight on the rear wheels were reduced by an amount W_s and the weight on the front wheels were increased by the same amount. Hence, it is customary to speak of this moment as a transfer of "effective" weight. As already stated:

$$W_sL = Fh$$

hence,

$$W_s = F\ (h/L) = MaR$$

The transfer of effective weight, therefore, is directly proportional to the deceleration.

If the center of gravity of the car were at the surface of the road, the maximum deceleration of a car having brakes on the rear wheels only would be given by the following:

$$a = F/M = Wfp/M = Mgfp/M = gfp$$

While the above condition is impossible, in that the center of gravity must always be above the road, the formula is often used in an attempt to calculate the maximum deceleration.

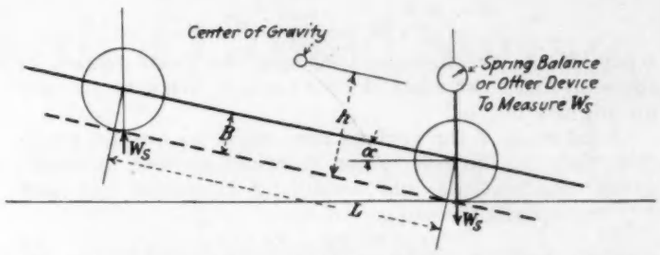

FIG. 2—SKETCH OF DEVICE FOR MEASURING THE EFFECTIVE WEIGHT SHIFTED TO THE FRONT WHEEL DURING DECELERATION
The Effect Is the Same as if the Weight on the Rear Wheels Were Decreased and That on the Front Wheels Were Increased by the Same Amount

Taking the transfer of effective weight into consideration gives the following results:

$$\begin{aligned} a &= F/M \\ &= W_rf/M \\ &= (pW - W_s)f/M \\ &= (pMg - MaR)f/M \\ &= pfg - aRf \end{aligned}$$

or

$$a + aRf = pfg$$

$$a = pfg/(1 + Rf) \qquad (1)$$

For cars with four-wheel brakes, under the assumed condition for maximum deceleration, namely, with all wheels locked, the relations become much simpler for, although a transfer of effective weight from the rear wheels to the front wheels takes place, its effect can be neglected as it increases the retarding force exerted by the front wheels to the same extent that it reduces the retarding force exerted by the rear wheels. Hence,

$$a = F/M = Wf/M = Mgf/M = gf \qquad (2)$$

Considering the quantities involved in equations (1) and (2), the value of g is known and p can be determined by weighing the car. R requires the measurement of both h and L. The latter, the wheelbase, is easily obtained, but the former, the height of the center of gravity, offers somewhat more difficulty. An experimental method that has been found satisfactory is shown in Fig. 2. H is given by the formula

$$h = (W_sL/W \tan \alpha) + B$$

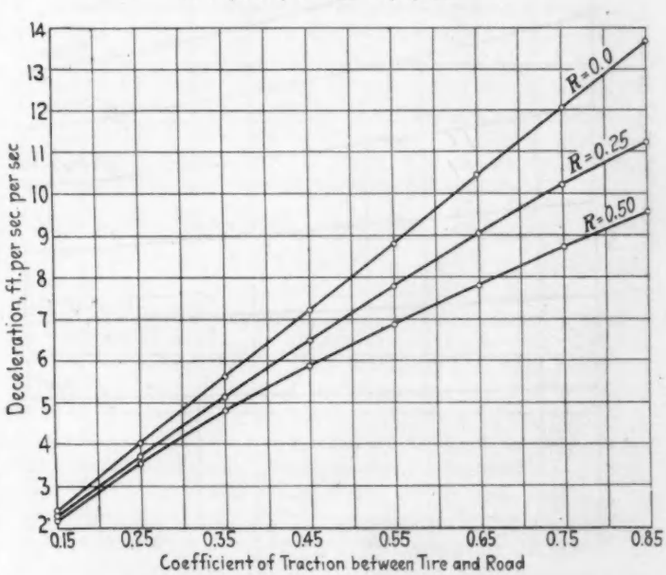

FIG. 3—CURVE SHOWING THE RELATION BETWEEN THE DECELERATION IN FEET PER SECOND PER SECOND AND THE COEFFICIENT OF FRICTION BETWEEN THE TIRE AND THE ROAD
The Weight of the Car Is Assumed To Be Distributed Equally between the Front and the Rear Wheels

$$R = H/L$$
$$= (W_s/W \tan \alpha) + B/L$$

where W_s is the increased load on the front wheels of the stationary car when the rear end is lifted to produce an angular tilt α.[2]

If values of f for various road surfaces are not available, they can be determined from actual tests by measuring decelerations and employing equations (1) and (2) transposed to read as follows:

$$f = a/(pg - Ra) \quad (3)$$
$$f = a/g \quad (4)$$

Equation (3) should be used with cars having two-wheel brakes only and equation (4) with cars having four-wheel brakes. Neither equation is applicable unless the braking wheels are locked.

Figs. 3 and 4 show graphically the results derived from equation (3), the former showing the relation between deceleration in feet per sec. per sec. and the coefficient of friction between the tire and the road; the latter, the relation between the deceleration and the ratio of the height of the center of gravity to the wheelbase, the value of p being assumed as 0.50 in both cases. Fig. 5 shows the relation between the stopping-distance and the speed for various decelerations and is derived from the familiar expression for conditions of uniform deceleration from a known to zero velocity, namely,

$$v = \sqrt{(2aS)}$$

[2] See *Automotive Industries*, March 13, 1924, p. 605.

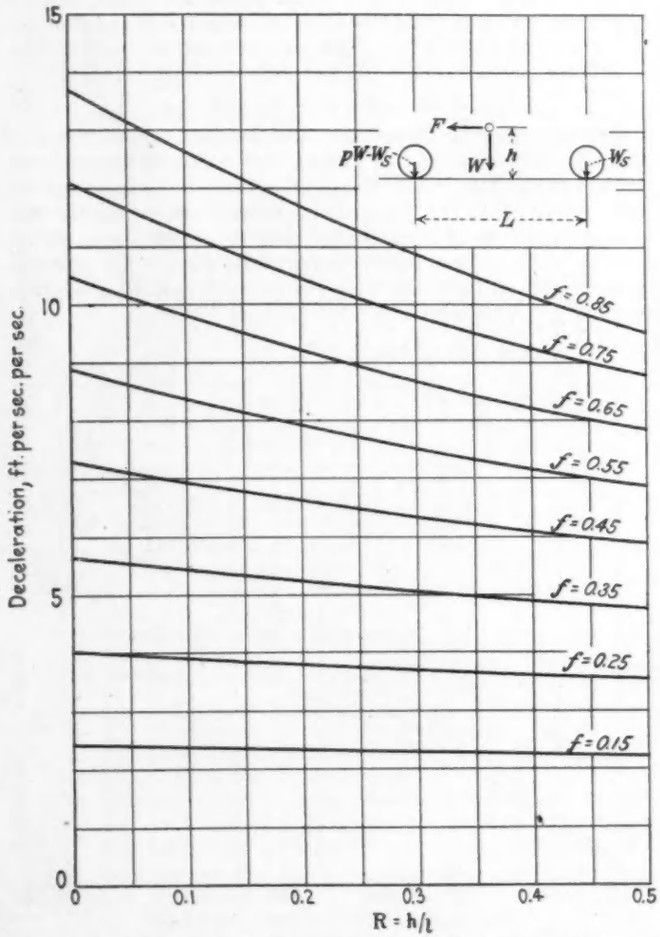

FIG. 4—CURVE SHOWING THE RELATION BETWEEN THE DECELERATION AND THE RATIO OF THE HEIGHT OF THE CENTER OF GRAVITY TO THE LENGTH OF THE WHEELBASE
The Weight of the Car Is Assumed To Be Distributed Equally between the Front and the Rear Wheels

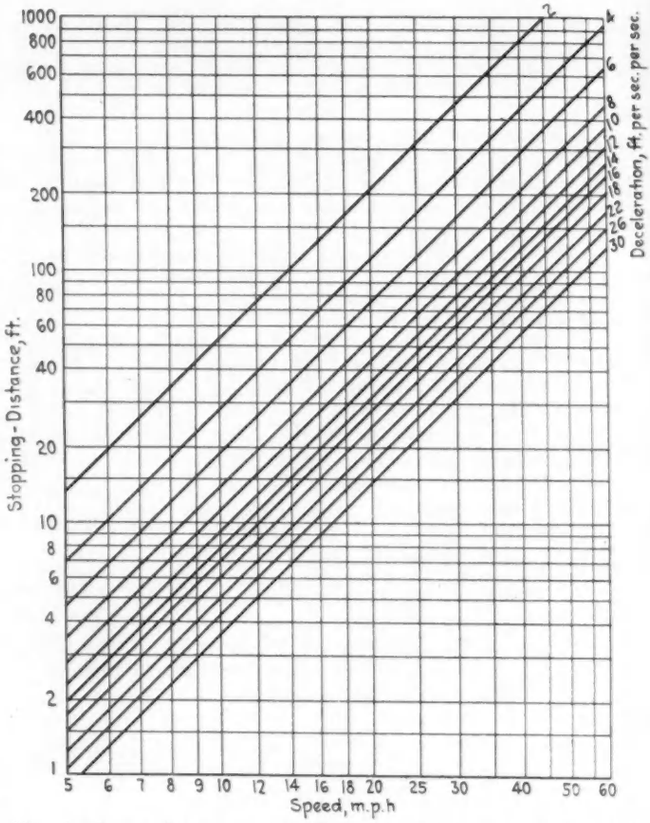

FIG. 5—CURVE SHOWING THE RELATION BETWEEN THE STOPPING-DISTANCE AND THE SPEED FOR VARIOUS DECELERATIONS
This Is Derived from the Expression for the Conditions of Uniform Deceleration from a Known to a Zero Velocity

In examining the foregoing relations, it will be observed that in every case the maximum deceleration is independent of the weight of the car and increases with the increase of the coefficient of friction between the tire and the road. For cars with two-wheel brakes only, the maximum deceleration increases as the percentage of weight on the rear wheels increases, as the height of the center of gravity of the car above the road becomes less and as the wheelbase becomes longer.

The extent to which the maximum deceleration in two-wheel-braked cars is affected by a change in the ratio R can be determined from equation (1). If for convenience K_1 be substituted for fpg and K_2 for f, then

$$1/a = (1 + RK_2)/K_1$$
$$= 1/K_1 + RK_2/K_1$$
$$-da/a^2 = K_2/K_1 dR$$
$$da/dR = -K_2/K_1 a^2$$

Resubstituting for K_2 and K_1 gives

$$da/dR = -a^2/pg$$

which means that the rate of change of deceleration with respect to R is as the square of the deceleration and in the opposite direction; that is, as R becomes greater, a becomes less and the rate of change is as a^2.

The reader should not construe the statement, that the maximum deceleration with four-wheel-braked cars is obtained with all wheels locked, as meaning that such a condition is desirable. It is very generally believed that it is desirable to sacrifice some braking ability for the sake of the better control of the car that is possible with the front wheels rotating. Hence, most cars are normally adjusted so that the front wheels do not lock. Hence, the equation for cars with four-wheel brakes gives a deceleration somewhat greater than is normally possible.

Calculation and Design of Coiled Springs

By E. W. Stewart[1]

Tractor Meeting Paper *Illustrated with* Drawings

ABSTRACT

In determining the characteristics of coiled wire springs, if all the component forces, including those of torsion, transverse shear, tension and compression, are considered, the calculation may be complicated and involved, but for practical purposes of design all can be ignored except torsion. The calculation then becomes simple. The underlying principles of the formulas that express the torsional characteristics of an ordinary helical spring are the same as those that govern torsion in a straight shaft; and the fact that the result would be the same if the shaft or wire were twisted in the opposite direction makes it clear why a coiled spring has the same stiffness in either compression or extension so long as all the coils remain open.

In Begtrup's formula, as given in the handbooks, the only unknown factor is the modulus G, which is variously stated to be from 10,000,000 to 14,000,000 lb. An average of hundreds of tests, however, has shown that, for drawn wire in all grades of carbon steel, whether tempered or merely hard-drawn, for alloy-steel and for music wire, the *true* modulus is 11,500,000 lb. and will not vary from this value more than plus or minus 3 per cent. This value is entirely independent of the hardness or the heat-treatment.

In a spring with squared and ground ends, properly closed, the number of active coils is the total number of coils minus two. The accepted formula for deflection in springs of square material, as set forth by Begtrup, is said to be incorrect, due to the assumption that a square section retains its shape when stressed, which is not true. The constant K, which varies with the shape, is unity for a round section but has been shown by Saint-Venant to be 0.843 for a square section.

The main points to be considered in designing extension springs are that stress calculations for a given deflection are misleading unless the stress stored up as initial tension is included, and that deflection does not start from zero load, as in a compression spring, unless the coils are not under tension when coiled. The spring of smallest diameter that can be produced commercially is that in which the mandrel size and the wire size are equal.

Special shapes of springs are infinite in number. Conical or barrel-shaped springs tend to decrease breakage. In torsion springs, the action within the wire is that of bending; for these, the derivation of the formula is partly experimental but is based on the fundamental formulas for beams. It is based on the assumption that the bar is straight when free; consequently, the load computed by it is greater than the actual load that a spring will develop. Expressing the deflection in terms of revolutions of the shaft on which the spring is operated and the load in pound-inches, and correcting the constant, enable a simple formula to be developed for the stresses in torsion springs, a subject not heretofore covered completely in any published work.

The designing of a spring involves a combination of a definite load with a definite deflection under that load; consequently, there is no such thing as a factor of safety in a spring, in the sense of that in a beam, but the use of proper judgment is urged.

Experiments show that the limiting factor in springs is the range of stress through which operation takes place from the initial to the maximum load, rather than the maximum stress, as has been supposed. If the test is so conducted that the spring is not allowed to relax to no load, the results will not be the same; it was found that a spring operated from the proverbial maximum of 80,000 lb., as an initial load, to about 86,000, as a final load, will run indefinitely. This range is not constant but varies with the analysis of material and with the temperature.

A uniformly sorbitic condition is the proper state for the best resistance to fatigue. A manganese content higher than that in the usual steels is best. Fatigue resistance depends on the condition of the surface. Cost must be considered and a compromise must be effected. Tolerances are a question of cost. What is a reasonable tolerance on a spring depends upon its proportions.

The conclusions reached are that the design of springs involves a knowledge of what the spring is required to do, the application of a few simple mathematical laws to determine its dimensions, a consideration of how accurately it must be held and the tempering of all these with ordinary common sense in keeping the stresses within reason.

THE characteristics of coiled wire springs can be determined mathematically with a great degree of accuracy by formulas that are extremely simple. It is possible to make the calculation of a spring rather complicated and involved, if all the component forces are considered, but some of the factors in these calculations can be ignored without producing serious error. An ordinary compression spring is subjected to four forms of stress when under load: (*a*) torsion, (*b*) transverse shear, (*c*) tension and (*d*) compression. Determining the dimensions of a spring to meet a given condition and considering all four factors involve elaborate calculations; but all the factors, except that of torsion, can be ignored for all practical purposes in design. The purpose of this paper is to convey an understanding of the simpler factors, with a view to their practical application, rather than to enter into an analytical discussion of the abstract mathematics involved.

Torsion Formulas the Same for Springs and Rods

The underlying principles of the simple formulas that express the torsional characteristics of an ordinary helical spring are the same as those which govern torsion in a straight shaft, for example, a straight rod of ¼-in. spring wire that is clamped firmly at one end with the other end mounted in a bearing and having a pulley with a groove at 1½-in. radius clamped to the rod with a set-screw. If the rod is exactly 20 in. from the clamp to the set-screw, a 100-lb. weight attached to a wire over the pulley will drop 1 in. This represents 1-in. torsional deflection in the rod, as measured on the circumference of a 3-in. circle. Now imagine the same rod to be of ¼-in. wire coiled in a helix of 3-in. mean diameter, placed with its axis vertical and the upper coil firmly clamped to a fixed support. If a clip be placed on the coiled spring thus made in such a manner that the distance around the coils is 20 in. as measured on the mean

[1] Sales manager, William D. Gibson Co., Chicago.

diameter, which would make 2⅛ coils, the 100-lb. weight attached to the lower clip will drop 1 in. as it did on the straight rod. In both cases a torsional moment of 100 lb. at 1½-in. radius is acting on 20 in. of wire with the same result. It is evident that if the wire over the pulley were dropped at the opposite side so as to twist the wire in the reverse direction, the result would be exactly the same. This makes it clear why a coiled spring has the same stiffness in either compression or extension so long as all the coils are open, which means, simply, so long as the length of the wire being deflected remains the same. It is only approximately true that the deflection is the same in a coil as in a straight rod, as the rod is in simple torsion, while the coil is subjected in some degree to direct shear, and to compression or extension within the material. None of these forces, however, is of sufficient magnitude to make much of an error in considering the action of a coil as equivalent to simple torsion. In the calculation of stresses in springs under severe loads, it is well to consider the stresses produced by direct shear, in addition to those produced by torsion, but the error due to neglecting bending and compressive stresses is much smaller than the errors in the calculated results, which are caused by the ordinary commercial variations in materials.

The derivation of the formulas for round bars or wire is simple and direct. From the fundamental formulas for torsion, the torsional moment,

$$M = SJ/c,$$

in which

c = the distance of the remotest fiber from the neutral axis
J = the polar moment of inertia of the section
S = the unit torsional stress within the material resisting the externally applied torsional force

For a round section,

$$J = \pi D^4/32$$
$$c = D/2$$

hence,

$$M = \pi SD^3/16$$

The torsional moment is also the load in pounds times the radius, or P_r which, in terms of the mean diameter in a circle, is $PD/2$.

Therefore,

$$PD/2 = \pi SD^3/16$$

from which

$$P = \pi SD^3/8D$$

which is the formula for load in terms of torsional stress.

The stress due to direct shear is equal to the shearing load divided by the area of the section. This, in a round section, is

$$4P/\pi D^2 = 1.274\,P/D^2$$

Since the load for a given deflection varies inversely as the cubes of the mean diameter of the coil, it follows that, for a given size of wire, this stress due to direct shear is greater for springs of small mean diameter. For this reason, the apparent elastic-limit of a spring, as expressed in terms of the deflection per coil that is possible without a permanent set, is greater for small than for relatively large diameters. The larger the ratio of the mean diameter of the coil D to the thickness of the wire d, the more nearly will the total stress be purely torsional. For the same reason, the shearing stress should always be taken into consideration in springs in which the ratio D/d is small, say less than 4.

These formulas do not include any factor expressing deflection but, in a straight shaft,

$$f = LDS/Gd$$

in which

d = shaft diameter
f = deflection at pulley diameter D, in.
G = torsional modulus of elasticity
L = length, in.
S = unit torsional stress

In a spring,

πD = the approximate length of one coil and, if N is the number of active coils,
πDN = the length of wire, closely enough for practical uses.

Strictly, the length of each coil is the hypothenuse of a triangle having a base equal to the circumference of the pitch diameter of the coil and an altitude equal to the pitch of the coil from center to center. To obtain this length with mathematical accuracy involves a calculation based on the cosine of the angle of inclination of the coils; hence, this pitch-angle must be determined. This is next to impossible when the number of coils in a given length is one of the unknown factors to be determined; and the variation in modulus from one lot of wire to another introduces a much larger variable than this error in length.

For all practical purposes, then,

$$f = \pi D^2NS/Gd$$

which expresses deflection in terms of stress. By simple algebraic inversion of the formula for load,

$$S = 8PD/\pi d^3$$

and of the formula for deflection,

$$S = fGd/\pi d^2N$$

therefore,

$$8PD/\pi d^3 = fGd/\pi d^2N$$

from which

$$8PD^3N = fGd^4$$

and

$$P = fGd^4/8D^3N$$

which is Begtrup's formula for load and deflection, so called because first published by J. Begtrup.[2]

For a given spring, in which all the physical dimensions are known, the only unknown factor in this formula is the modulus G, which has been variously stated by different authorities to be from 10,000,000 to 14,000,000. As a matter of fact, no such variation exists, and the small deviation from an average value is the thing that makes the calculation of springs practicable. In determining the true value of the torsional modulus, the method we have adopted eliminates any error due to the effect of active or inactive coils, as we center-punched marks at the center of the wire or bar of the springs tested, exactly two coils apart, and in springs of a sufficient number of coils to allow two coils to be entirely free at all points. With the springs under an initial load in a testing-machine, the exact distance between the punch-marks was measured by a hair-line telescope with cross-hairs over the lens and mounted on a vertical micrometer-screw. A definite further load was then placed upon the springs, and the distance between the punch-marks was again measured. The difference was the deflection under the added load of exactly two active coils, and the modulus was figured for each case by inverting the formula. The average of hundreds of such tests is remarkably close for a given size and character of material.

For drawn wire in all grades of carbon steel, whether tempered or merely hard-drawn, for alloy-steel and for music wire, the modulus is 11,500,000 and will not vary from this value more than plus or minus 3 per cent. For hot-rolled bars, the value is less, whereas, the effect of cold-working the wire in the drawing dies increases the modulus to a certain extent. Hot-rolled steel in small

[2] See *American Machinist*, Aug. 18, 1892, p. 2.

sizes is partly worked with more or less the same effect; hence, the modulus decreases as the diameter of the bar increases.

In sizes of hot-rolled stock around ⅜ in., the modulus averages about 11,200,000 and gradually falls to about 10,600,000 in sizes around 1 in. and larger. This value of G is entirely a characteristic of the material and is completely independent of the hardness or the heat-treatment. The impression is general that a spring can be stiffened by a harder temper; but it cannot be done. The stresses to which springs can be subjected within the elastic limit, or before they show permanent set, vary with hardness; but the rate of increase in the load for a given unit of deflection is not affected by any change in hardness.

The question of how many coils are active in a spring depends upon the finish of the ends. With a squared and ground end, properly closed, the end of the wire is in contact with the adjacent coil, but does not lie along it. With this condition at each end of a compression spring, one coil at each end is inactive, or "dead"; consequently, the number of active coils is two less than the total. If the end coils are closed into contact with the adjacent coil for a greater distance, the number of active coils will be less by whatever part of a coil is in contact at each end. In this variation lies much of the lack of uniformity in load characteristics of commercially produced springs. Naturally, this effect is much more apparent in springs containing only a few coils than in long springs having a large number of coils. For purposes of design, however, it must be assumed that the ends are closed as they should be, and that the active coils are the total number minus two.

Springs of Square Material

For springs of square material, the basis of the formula used is the same as for round, but the polar moment of inertia of the section is, of course, different. The value for square sections is $2d^4/9$.
Hence,

$$PD/2 = 2Sd^3/9$$

and

$$P = 4Sd^3/9D$$

which expresses the load in terms of the stress.

The direct shear value for a square section is simply

$$S = P/d^2$$

The accepted formula for deflection in springs of square material, as set forth by Mr. Begtrup and widely published in various handbooks, is incorrect. This formula was based on the theory that a square section retains its shape when stressed, which is not true.. Saint-Venant has shown that the maximum stress is at the middle of each side and that distortion of the section increases deflection.

The general formula expressing torsional characteristics, as based on his investigations, is, for any section,

$$f = [(I_1 + I_2)/(4\ I_1 I_2)] \cdot [Pr^2L/KG]$$

in which

G = the torsional modulus of elasticity
I_1 = a plane moment of inertia through the major axis
I_2 = a plane moment of inertia through the minor axis, at right-angles to I_1
K = a constant, which varies with the shape of the section.
L = the length in inches
P = the load in pounds
r = the radius at which the load is applied

This constant is unity for a round section, and assuming this constant as unity for a square section is the source of the error in the Begtrup formula. Saint-Venant gives this constant as 0.843 for a square section, the reduction of the general formula becoming

$$f = 2.48\ SD^2N/Gd$$

and

$$P = fGd^4/5.59D^3N$$

in which

d = the side of the square

These formulas check very closely with actual tests, whereas the published formulas do not. Another important point about springs of square wire is that the wire changes from a square to a trapezoidal section in coiling. As a consequence, the solid length of a spring of ordinary proportions is considerably more than the product of the number of coils and the original size of the wire. An investigation of this feature produced a simple empirical formula that answers this question.

The spring of smallest diameter that we can produce commercially is that in which the mandrel size equals the wire size; hence, the ratio of the mean diameter of the spring to the size of wire, at the condition of maximum upset to the wire, is 2 to 1. When this ratio is large enough, there is a point at which the upset does not occur; and we reasoned that the ratio of the outside diameter to the mean diameter, D_o/D_m, includes the original wire size, is greatest at the condition of the worst upset, and approaches unity as the diameters increase. When we tried multiplying this ratio by the original size, the values were too high. We then tried an average between this value and the original size, or

$$0.5\ [(D_o/D_m d) + d]$$

which was close. After making a number of tests, we corrected this 0.50 factor to 0.48; and this checks up about right. Simplified, this average value becomes

$$0.48\ d\ [(D_o/D_m) + 1].$$

The surprising thing about this simple relation is that it makes almost no difference in the final dimension whether the wire is coiled cold or hot, nor at what temperature, the thickness at the inside coming out about in accordance with the formula. This upsetting condition gives rise to a considerable variation from calculated results in springs of square section in which the diameter is small in relation to the wire size. The extreme upset on the inner side in such a case produces a section because of which the true neutral axis is inside the mean radius of the coil. This can be closely estimated from a finished spring by measuring the finished section, but for purposes of design it is very difficult to know just what effective mean diameter to select. Such springs, however, are poor practice, for the mean diameter should never be less than four times the size of the wire, if this can possibly be avoided, both because of the difficulty just mentioned and because the combined torsional and shearing stresses are bad.

Extension or Closely Coiled Springs

All the foregoing discussion deals with compression springs of the straight helical type. By far the larger percentage of springs in use is of this kind, but extension springs, or closely coiled springs, follow the same principles. The illustration already given, namely, that it makes no difference in the results in which direction a shaft is twisted, applies here. The only difference between compression and extension-spring calculations is that in the latter the springs are usually coiled with what is termed "initial tension." This is pressure between adjacent coils when the spring is at rest; and such a spring will support part of its load before any

deflection, or increase in length, occurs. This initial tension can be varied widely according to the method of coiling but, in the average run of commercial springs, it is a load in pounds equivalent to a torsional stress in the wire of between 10,000 and 15,000 lb. per sq. in. After this load has been overcome and the coils are actually separated one from another, any further deflection is in direct proportion to the load and follows the same formulas as those for a compression spring.

The main points to be considered in designing extension springs, or in checking existing spring designs, are that stress calculations for a given deflection are misleading unless the stress stored-up as initial tension is included, and that deflection does not start from zero load, as in a compression spring, unless the coils are not under tension when coiled. It should also be borne in mind that hooks or loops turned up at the ends produce highly localized stresses where the loop leaves the coil, as bending and tensile stresses of considerable magnitude are added to the torsional stresses at these points. For this reason, all bends should be made with as large a radius as possible, to prevent complete localization of these stresses in a sharp bend. For the same reason, extension springs should be designed to operate at much lower stresses than would be good practice in compression springs for the same load.

Conical Springs a Cure for Valve-Spring Breakage

Apart from ordinary straight compression and extension springs, the variety of special shapes for special purposes is almost infinite. Many special ideas have been tried in compression springs with a view to overcoming inherent troubles in ordinary springs, particularly in engine valve-springs. Some features of conical and barrel-shaped springs are worthy of mention. In a number of high-speed engines we have encountered breakage in straight springs of apparently good design as to stresses, the breakages being localized about one and one-half coils from one end. It was obvious that defects in wire would not explain this.

We found that the end next to the solid engine-block was getting the breakage because of vertical vibrations of the spring within itself. The coils would float up to a certain point where the rigidity of the block was supporting the end coil and, at that point, a severe whipping action would break the wire. It was found that this condition was worst at certain speeds, that is, when the periods of the engine synchronized with the periods of the spring.

A conical or a barrel-shaped spring goes far toward correcting both conditions. The gradual change in diameter of the end coils tends to prevent localization at any one point, and the diameter's varying from coil to coil tends to break up the periodicity sufficiently to prevent "floating" springs. In any style of spring with tapered diameter, the pitch should be proportional to the diameter so that the coils will all close solidly under the same load. If a conical spring is made with a uniform pitch, the larger coils, being weaker, will close at a light load, and will reduce the active length of wire for the remainder of the travel. The stress-strain diagram for such a spring is a sharply rising curve; the calculation of load at any given point of travel is very difficult; and a deflection per coil that is entirely safe at the large end may be beyond the elastic-limit at the small end. In either a conical or a barrel-shaped spring, with the pitch regulated to the same solid stress, as we think it should be, the stress-strain diagram is a straight line, and equals that of a straight helical spring having a mean diameter that is the average of the smallest and of the largest coils.

Torsion Springs

Springs used in torsional action, in which a helical coil is operated through a twisting motion, are called torsion springs. They present an entirely different problem from springs used in compression or extension. In the latter, the action is torsional within the wire; but, in torsion springs, the action within the wire is bending.

The derivation of a formula for torsion springs has been partly experimental, but is based on the fundamental formulas for beams. These formulas, however, can be true only if the bar resumes the position of a straight line when free, hence, cannot be strictly applied to a coiled spring. The basis, however, of the experiments conducted was the general formula for the deflection of a beam,

$$f = MLR/EI$$

in which

E = the modulus of elasticity for tension
f = linear deflection on a circumference of radius R
I = the moment of inertia
L = the length of the bar
R = the radius through which the bending-moment M acts

This formula does not apply except to a beam that is straight when released from load; but carrying out the same transposition as before into terms of coils instead of length produces

$$f = 16\,PD^3N/Ed^4$$

This would be a difficult formula to apply, even if it were true, as the deflection is in terms of inches on the mean circumference, the dimension of which might very often be one of the factors to be figured. It was deemed advisable, for many reasons of convenience, to throw this into terms of revolutions of the shaft on which the spring operated. Then, for 1 revolution,

and

$$f = \pi D$$
$$\pi D = 16\,PD^3N/Ed^4$$

and for 1 turn

$$P = \pi Ed^4/16\,D^3N$$

It further simplifies matters to consider the load in terms of pound-inches, rather than load at the coil pitch-circle. Then, the load in pound-inches is to the load at the pitch radius $D/2$, as $D/2$ is to 1, and

$$P \text{ (per turn in pound-inches)} = \pi Ed^4/16\,D^2N \times D/2 = Ed^4/10.2\,DN$$

As stated before, the deduction of this formula is based upon the assumption that the bar is straight when free; consequently, the load computed by it is greater than the actual load that a spring will develop. The factors in the simplified formula last mentioned, however, must necessarily govern; and it became a matter of research tests to correct this constant, 10.2, to one that checked with results. After a great many such tests on springs of all sizes, it appears that the correction of this constant to 11.5 does the work. In other words, the formula corrected to

$$P \text{ (pound-inches per turn)} = Ed^4/11.5\,DN$$

will figure torsion springs as they perform, and the deflection can easily be transposed into turns, or decimal parts of a turn or 360 deg., and loads to pound-inches. We find this to be the most convenient form in which to handle these calculations, especially with the slide-rule.

The calculation of stresses in a torsion spring has not been covered with any degree of completeness in any published work on springs, but is a simple matter when

we analyze what happens. The main component is a direct cantilever-loading at every point on the coil, as illustrated in Fig. 1, and is the moment PR, or load times radius, applied to section d, the section modulus of which is $\pi d^3/32$. This cantilever loading therefore produces a stress

$$S_c = PR/(\pi d^3/32)$$
$$= 10.2\ PR/d^3$$

This stress is the extreme tensile stress at the outside and the extreme compressive stress at the inside of the wire, with a zero stress at the neutral plane through the center, so far as bending is concerned. The entire sectional area of the wire, however, is also subject to a direct tensile stress set up by a tangential pull on the wire at right-angles to the cantilever loading and also acting at all points on the coil simultaneously. This load P applied at radius R, with a fulcrum at the center of the coil, acts on the wire directly at the pitch radius of the coil, which is $D/2$. This stress, therefore, is the load divided by the area or,

$$PR/(D/2) = (2\ PR/D) \times (4/\pi d^2)$$

hence, the tangential pull is

$$S_t = 8\ PR/\pi D d^2$$

The total stress is therefore

$$S_c + S_t = 10.2\ PR/d^3 + 8\ PR/\pi D d^2$$

For the purpose of rapidly determining the dimensions from which to estimate a design, it was desired to know how many turns were possible within the elastic-limit in a torsion spring of average commercial material. These springs are generally made of wire that has been hardened and drawn to the proper spring temper at the mill. This tempered wire is coiled on a mandrel smaller than the finished inside diameter desired, and allowance is made for the recoil, or "spring-back," of the wire when released from the tension placed upon it in coiling.

Thus, the recoil determines the elastic-limit, as the wire is permanently set when coiled, and the number of turns that a spring recoils from the mandrel when released is the number of turns that it will operate or wind-up before the permanent set begins. In other words, a finished spring will stand winding-up until the inside diameter has been reduced to the size of the mandrel on which it was originally coiled, beyond which the effect is the same as recoiling on a smaller mandrel.

We reasoned that the elastic-limit was so nearly constant that we could reduce this to a simple formula, as the number of turns of relaxation from the mandrel would vary directly as the mean diameter D, directly as the number of coils N and inversely as the diameter of the wire d. Hence, the total turns would equal ND/Kd, in which K is an experimental constant.

As we could check any number of tests of this formula by simply counting the back-up turns as we coiled long lengths of wire in production, we obtained a considerable number of such tests; and the minimum value obtained for this constant was 85, the maximum, 94 and the average, 88. From these data we have since figured the elastic limit roughly in terms of the number of revolutions U as

$$U = ND/88d$$

By combining this with the deflection formula, the pound-inches for U turns which we will designate as X is given by the equation

$$X = Ed^4/11.5\ ND \times ND/88d$$
$$= Ed^5/(11.5 \times 88)$$

Since E averages 29,500,000, the approximate elastic limit, in pound-inches, becomes simply $29{,}000\ d^5$.

Allowing a reasonable factor of safety against these extremes, we are using these three formulas very successfully for torsion springs in our present practice:

Pound-inches per turn, $Ed^4/11.5\ ND$
Pound-inches for safe load, $20{,}000\ d^3$
Total turns for safe deflection, $ND/130d$

The designing of a spring varies from that of ordinary structural or machine details, in that it is not enough to ensure sufficient strength and rigidity but usually involves a combination of a definite load with a definite deflection under that load. Consequently, there is no such thing as a "factor of safety" in a spring, in the sense of that in a beam, for instance.

The only factor of safety that can be applied in spring

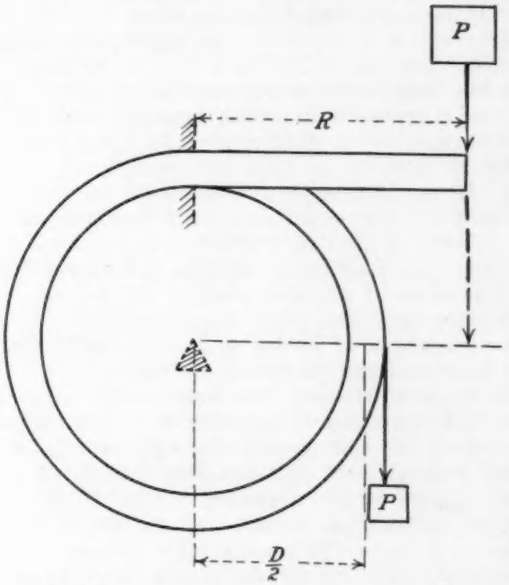

FIG. 1—CALCULATION OF STRESSES IN A TORSION SPRING
The Load P Applied at Radius R, with a Fulcrum at the Center of the Coil, Acts on the Wire Directly at the Pitch Radius of the Coil, Which Is $D/2$

design is the exercising of proper judgment in selecting a combination of dimensions that will provide the necessary strength and rate of deflection and that will do both with an applied stress within the material that it will stand for a sufficient number of repetitions to produce a satisfactory length of life. Consequently, the application of formulas for design purposes involves a knowledge of stress limitations for the conditions under which the proposed spring is to operate.

To get what information we have on this subject has involved considerable research, and the related problems of stress possibilities under varying conditions of speed and temperature and the manufacturing problems of producing materials to meet these conditions involve much more yet to be done before we can say that they have been solved. We know, however, that what information on this point has been published in the handbooks needs to be expanded and supplemented greatly to cover the subject with any completeness.

RANGE OF STRESS IMPORTANT

The theory has been advanced that the limiting factor in springs is the maximum stress in operation. Experiment shows that the important factor is the range of stress through which operation takes place from the initial to the maximum load. In an automobile valve-spring, for instance, we have found that springs will operate through a short range of stress, such as is repre-

sented by a 5/16-in. lift, with stresses at the cam peak position that would promptly result in fracture, if the spring were operated from its free length to the same stress. Fig. 2 represents torsional stresses plotted against thousands of spring movements, or repetitions of stress from zero stress upward, as from the free length.

This test was made of duplicate springs made from a single bundle of wires of S.A.E. No. 1360 steel, all heat-treated exactly alike. The pitch was such that the deflection of each coil when solid represented a stress of 145,000 lb. The first spring was started at that stress and run from zero to 145,000 until it broke; another was then tested at 140,000 lb., and others at deflections successively reducing the stress in steps of 5000 lb. The resulting curve is almost a true logarithmic curve from the elastic-limit at 145,000 to a flat line at about 48,000. Thus, the fatigue-endurance limit of this wire is somewhat less than 48,000 lb., when operated from zero stress.

If the test is so conducted that the spring is not allowed to relax to no load, the results will not be the same. If the loading is started from an initial stress of 10,000 lb., the endurance limit is above 48,000; if from 20,000, it is still higher; and we have actually found that a spring operated from the proverbial handbook maximum of 80,000 lb., as an initial load, to about 86,000, as a final load, will run indefinitely. A relation exists somewhere of stress maxima to deflection range which is the answer to spring fatigue.

This range of stress is not constant for all steels but varies with the analysis and also with the temperature under which the springs operate. Apparently, it is not affected materially by speed within limits, as we have broken springs at given ranges within 10 per cent of the same number of movements at 250 and at 1400 strokes per minute. It is materially affected by changes in the heat-treatment of the metal; and a uniformly sorbitic condition is the proper state for the best resistance to fatigue.

We have known for many years that a manganese content much higher than that in the usual steels is best for springs, partly because it is sorbitic in condition over any reasonable variation in heat-treatment, partly because it is tougher under repeated stress, and lastly because it is a better material to handle in wire-drawing. The steels standardized by the Society a few years ago, as S.A.E. Nos. 1350 and 1360, contain the commercial analysis of the best grades of carbon-steel spring-wire.

Use of Alloy-Steels

The design of springs sometimes involves the necessity for getting the best results possible within dimensions already limited, under a condition in which low stresses are impossible. Some alloy-steels, notably chrome-vanadium and silico-manganese, can be operated at higher stresses than can carbon steels and, at a given stress, if high, will stand up for a greater number of repetitions of stress. It has been our experience, however, that no advantage lies in the use of alloys in springs, if the stresses are within the fatigue range of good carbon-steel. In any case, a high-grade clean carbon-steel, low in phosphorus, is better under any conditions than a dirty alloy-steel of any analysis. We have formed the opinion from our experience that, if it is worthwhile to make springs of an alloy-steel at all, the benefits desired can be obtained only by the use of high-grade electric-furnace products that are clean and free from segregations.

[3] See *Iron Trade Review*, March 31, 1921, p. 895.

The greater resistance to fatigue of the alloy-steels seems to me to be due to the fact that they retain the required physical properties at a higher draw. When a piece of steel is annealed fully, it is in a state of internal equilibrium with its crystalline structure at rest, so to speak. If heated above its critical range and quenched, it hardens with a crystalline structure under very high internal-stresses. If it is again heated to the critical temperature, this condition of internal stress is removed, and the nearer the draw-back temperature approaches the temperature of full annealing, the less internal-stress will be retained. This explains, at least in part, why a chrome-vanadium-steel spring will outlast a carbon-steel spring at high stresses, as it can be drawn at 1000 deg. fahr. and will hold the elastic-limit up to about the same point as will a carbon-steel spring drawn at 700 deg. fahr.

Condition of Surface and Fatigue Resistance

Fatigue resistance depends largely on the condition of the surface also. In round wire under torsion, the work is largely done at the surface, as the stresses reduce from the maximum at the surface to zero at the center. Hence, any imperfections, however small, tend to localize stresses and to increase them. In a very small way they are like nicking a bar to break it. Decarbonization at the surface, due to faulty heat-treating in an oxidizing atmosphere, is another source of trouble, as it reduces the elastic-limit at the surface, causing the decarbonized "skin" to take a permanent set and, in effect, reducing the size of the wire from a stress standpoint, as the actual load is maintained on a smaller effective section.

Professor Moore, of the University of Illinois, has explained the nature of fatigue breaks very clearly.[3] He says in part:

> Any sharp discontinuity in metal, due either to a surface defect or to an internal flaw, greatly increases the stress in the metal over a microscopic area around it. As an example, the stress near the bottom of a sharp notch may be five or six times as high as a stress a few hundredths of an inch away from the notch. These localized stresses are of negligible account for structural and machine parts subjected to a few loadings but may be of the greatest importance in the case of parts subjected to many thousands of loadings. The progressive spread of small cracks is offered as an explanation of the failure of springs while under the action of light loads. At some time in its life, a spring is liable to be subjected to heavy loads. These heavy loads start microscopic cracks, but are not repeated often enough to cause them to spread far. However, the microscopic cracks are in themselves very sharp notches and cause high localized stresses under subsequent light loads with consequent spreading of the cracks and final failure.

From this it would seem that the logical answer is a highly polished surface; but the objection to all such things is cost. None of us can afford to consider springs or any other machine part without figuring on this item, for we are all engineering for profit. The answer must be a compromise between ideals and practical possibilities; but an opportunity exists for much constructive cooperation between manufacturers of spring wire and bars and the spring makers with a view to the improvement of the surface without too much increase in cost.

Tolerances

The question of tolerances on springs, as to dimensions and load characteristics, is also largely one of cost. During the war, we made Liberty engine valve-springs to a limit of 1 deg., plus or minus, as to squareness of

ends, and to 3 per cent, plus or minus, as to the load at a given height; but cost was not a factor. Under such conditions anything can be done that is physically possible. But when the engineer must design down to a price, as he usually must, it is well to consider that, so far as springs are concerned, a load limit of 10 per cent, plus or minus, can be maintained with ordinary care and watchfulness in commercial production, except in exceptional cases, but that tolerances much under this mean culling out and scrapping part of the production and more or less handwork on the rest, all of which adds to the cost.

What is a reasonable tolerance on a spring depends upon its proportions. For instance, a spring of ¼-in. wire and 1-in. outside diameter can be ground very nearly perfectly, as it is stiff enough to handle well. But a spring also of ¼-in. wire but of 4-in. outside diameter cannot be held within 5 deg. at the ends because of its flexibility. The same is true in each case as to length: a pitch of coil, if of 1-in. outside diameter, can be held fairly uniform, but this is very difficult with a coil of 4-in. outside diameter.

As to loads, take for example an automobile drag-link spring that has a very high load-deflection rate and a very short initial-compression, say 1600 lb. per in., and a load requirement when assembled at a definite height. In such a case, a variation of 1/64 in. in free length means a variation of 25 lb. in the load at the assembled height, even with no variation in the rate per inch, which would vary also.

In a clutch spring, however, in which the free length is as long as possible for a given compressed height to hold down the increase in load through the pedal range, a variation of as much as ¼ in. in length might produce a variation in load of less than 25 lb., yet the actual load when assembled might be about the same in both cases.

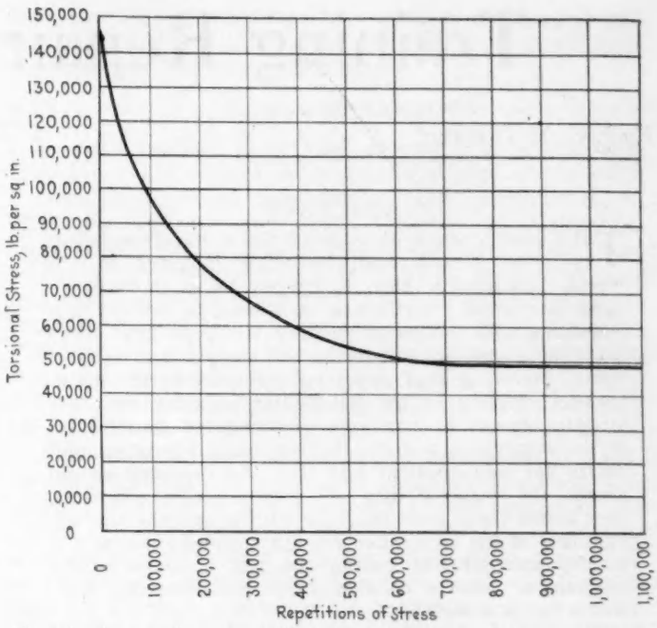

FIG. 2—CURVE SHOWING TORSIONAL STRESSES PLOTTED AGAINST THOUSANDS OF SPRING MOVEMENTS, OR REPETITIONS OF STRESS FROM ZERO STRESS UP

Duplicate Springs That Were Made from a Single Bundle of Wires of S.A.E. No. 1360 Steel, All Treated Exactly Alike, Were Used

To sum up, the design of springs involves a knowledge of what the spring is required to do, the application of a few simple mathematical laws to determine its dimensions, a consideration of how accurately it must be held, and all these must be tempered with ordinary common sense in keeping the stresses within reason.

LATIN-AMERICAN TRADE

THE expansion of United States trade in Latin America does not necessarily mean that other countries will have less trade there. No limit can be set to the trade that may be had there if the resources of these countries are opened up. Every one of the countries now trading there can have more trade if it will do its share to increase the purchasing power of these peoples.

Too much loose and meaningless talk has been heard about national rivalries and of this or that country driving other countries out of the field. Competition exists, of course; competition is the law of life, and nobody should want exemption from it. We have plenty of competition in the domestic trade of this Country, and a reasonable degree of prosperity with it. We hear considerable about the prospects of German competition in the markets of the world; but we had German competition in all those markets before the war, when Germany was in the full tide of her power, and it is well to remember that in those years the volume of German imports always kept pace with that of the exports from that country.

A lesson is contained in this which seems difficult to learn. Nations pay for what they buy of each other with their own goods and services, and if unwilling to take their pay in that manner they cannot sell for very long. This is one thing we have not fully learned in this Country. We are great for foreign trade, but most of us mean selling. And yet a good merchant is bound to give some attention to how his customers are going to pay for what they buy. We must understand that if we are to sell to Latin America, we must take in payment the products of Latin America without grumbling or restriction.

And we must consider that trade with Latin America is closely involved in trade with other parts of the world. At present we have a great balance in our favor in trade with Europe, which Europe is able to settle by transferring to us balances that are coming to her from South America and other parts of the world. We cannot have trade balances in our favor from all parts of the world, for no way of paying them will be found. We must understand that our position is changing from that of a debtor country, which requires a surplus of exports over imports, to that of a creditor country, which requires a surplus of imports over exports.

One of the criticisms commonly directed at the labor organizations is that they sometimes restrict production, acting upon the theory that there is only a limited amount of work to be done and that the longer they can make it last and the more they can make it pay, the better. That is a mistake, but the statesmen of the world, and business men, too, sometimes fall into the same error. The truth is that no limit can be placed upon the amount of work to be done in the world, or upon the amount of business to be had, or upon the amount of wealth that can be created from the resources of nature. The purchasing power of every country is in its own powers of production, and the greatest possible prosperity for every country is to be had in connection with the prosperity of every other country.—G. E. Roberts in *American Bankers Association Journal.*

Training Repair Shop Personnel

By J. F. McDonald[1]

Service Meeting Paper

ABSTRACT

THE maintenance division of the automotive industry, the largest manufacturing industry in the world, has always been hampered by a shortage of good mechanics. Little has been done to remedy this condition, and we go on holding the hope that when the time comes some miracle will supply our need of men. Believing that opportunities exist in the maintenance division of the automotive industry that are stepping-stones to positions of unlimited possibilities if the applicants possess the necessary education and desire for advancement and that the industry should accept the responsibility of systematically educating men to fill these positions, the author outlines the advantages of the apprenticeship system and explains the results accomplished during the last 9 years in the mechanical schools conducted by the company with which he is associated.

The course of study is described, the topics covered are set forth, and the progress of the student is followed as he advances from one department to another. The importance of the proper selection of candidates and of attention to the family connections, education, companions and habits of the young men is stressed and the benefits that will accrue to those who complete such a course are emphasized. Having been used for years by railroad and contract shops in developing their men, the apprenticeship method, in the opinion of the author, is one of the many good things worked out by other industries that might be transplanted into the automotive industry with far-reaching benefits.

THE automotive industry is listed in recent reports as the largest manufacturing industry in the world; the maintenance division is the largest division of this industry. When these facts are considered, therefore, it would seem that good reasons exist why a young man who has finished school should look kindly toward entering the maintenance division of the industry.

The opportunities in the maintenance division are greater than those of any other division; in fact, they are stepping-stones to positions of unlimited possibilities. The maintenance division in recent years has progressed by leaps and bounds. Today, a distributer, a branch or a dealer to be successful must have a good service department capable of rendering efficient and satisfactory repairs at a nominal cost. Furthermore, the customer must be treated courteously. To bring about this satisfactory condition, proper equipment is necessary and employes must be educated to use that equipment with a high degree of efficiency.

Education causes us to be courteous and polite, to use proper language in the proper place, to be careful about our clothes and our physical condition; in fact, it makes us better men in every way. The maintenance division of the automotive industry is fast eliminating uneducated employes who disregard the rules of discipline, in favor of those who go into the division with a certain degree of education and with the idea of improving themselves. Certainly, an employe who improves himself will improve the organization.

The maintenance division has always been hampered by a shortage of good mechanics. Very little has been done to remedy this condition. We let the matter drag along and hope, when spring comes, that some miracle will occur by which we shall not need mechanics. If we had no business, we should not need mechanics; but I am absolutely certain that we do not wish this condition to exist.

I firmly believe that we must accept the responsibility of educating our men; and the larger the distributer, branch or dealer, the more of this responsibility must he accept, for unquestionably he has an opportunity to put into force some sort of training, with a view to creating good mechanics; and the only way in which he can do so is to begin with good material and educate it systematically.

It is my opinion that, as a general rule, the maintenance division has not been "sold" as it should be to the fine young men of this Country. I do not think we reach out and get the caliber of young man that we should be able to get. I can remember when I began my apprenticeship, it was considered a wonderful thing to begin in a contract shop; in fact, many young boys swept floors and did odd jobs in the shops, while waiting their turns to be placed as apprentices. These young fellows came from good families, were well-bred and had a certain degree of education. Apprentices' wages in those days were $0.08 per hr. for the first year, $0.10 for the second, $0.12 for the third and $0.14 for the fourth.

Value of Experience

I believe the answer is to apply to the automotive field a system along the same lines. What do wages mean to a young fellow for the first 2 or 3 years, if he profits by the experience and improves his position later in life, in other words, if he gains something that cannot be taken away from him; an education? It is true, no doubt, that a young man can get a job driving a grocery wagon, or clerking in a store, at wages several times those paid an apprentice; but I believe that, for the most part, a young man should obtain something that will materially benefit him and be of use to him later in life; a living asset.

The maintenance division has been flooded with so-called mechanics, who probably have picked up what they know by floating from one dealer's organization to another; and because of the scarcity of mechanics we have practically been compelled to hire workmen of this type. I have seen one of these so-called mechanics place a hack-saw blade backward in the frame and begin to use it, wondering what was the matter. I have seen mechanics spoil oil lines in endeavoring to bend them, not knowing that copper tubing can be annealed. How many boys in the maintenance division can use a file as it should be used, without rocking it? It is surprising how many reamers are broken because a repairman backs up the reamer when it chokes or loads up with chips and, as a result, breaks a blade. If it happens to be an expansion reamer, from $8 to $12 is lost, all because of backing up the reamer, instead of releasing it by turning the reamer in the same direction and pulling up on it at the same time. I could give such examples indefi-

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nitely. They demonstrate the fact that, as a rule, the mechanics that make automobile repairs have not been trained like those in other lines; and, because of lack of training, the industry is suffering an enormous loss.

Specific Instruction Needed

The process of education should not be of the veneered type, but should apply to the particular work in which the employe is engaged. In other words, do not try to make a chemist out of a repairman. Some time ago, a bright young man, well educated, applied for a position in the mail service. He naturally felt confident that he would pass the Civil Service examination without trouble. On the day of the examination, when the papers were distributed, to this young man's surprise, the first question read: "How far from the earth is the sun?" His answer was as follows: "Far enough so that it will not interfere with the distribution of the mail." I believe this young man should have been given 100 per cent on this particular answer.

Now, to "get down to brass tacks" as to what we have been doing and are contemplating doing to train young men, the company with which I am associated has been conducting mechanical schools for 9 years. We realized 9 years ago that something must be done, and that it was important that we should improve our employes' knowledge of our product, explaining why certain elements were built into the car, the troubles that might occur, how repairs were to be made and the remedies for troubles.

When the mechanical schools were first opened, one man could give the instruction very successfully but, as the school grew, we found that more attention was required than one man could give it; so, today, we have a committee for conducting the work of the school. Once a year, previous to the beginning of the mechanical school sessions, the committee meets and elects a chairman; thenceforth, meetings to discuss matters pertaining to the school are called weekly by the chairman.

Composition of Committee

The committee, consisting of the heads of the service department, outlines the school course, sets forth the subjects, selects the instructors for various subjects and makes arrangements for outside speakers to cover such subjects as batteries, electrical equipment and lubrication. We occasionally illustrate the talks with lantern-slides and always have on hand the particular parts of the car that are to be discussed at that particular session, as well as charts and a blackboard. A chassis is used to a great extent.

Last year's program consisted of 12 sessions held at 2-week intervals and covered carburetion, brakes and brake-drums, cooling-systems, lubrication of the engine, lubrication in general, clutches, transmissions and universal-joints, special shop-tools and equipment, engines, bearings, pistons, crankshafts, cylinder-blocks, rear axles, cylinder-heads, valves, push-rods, timing-gears, camshafts, storage-batteries, chassis, frame and allied parts, lighting, warning signals, electrical system, top, body and windshield and a general review and discussion.

The school sessions are held at our main station in Cleveland and the various service department heads in the territory are invited to attend them. We serve dinner in our dining-hall at 5:30, without charge. The school sessions begin promptly at 6:30. The attendance at the dinner is registered by the secretary of the school committee. Before beginning a session, cards are distributed on which each of those in attendance writes his name and that of the dealer by whom he is employed and suggestions of any kind. The suggestions that we have received have been very beneficial.

Branch Schools

We have realized from year to year that it has been difficult for the dealers in the southern part of the state to come to Cleveland to attend all these sessions, so, in 1923, we opened mechanical schools in Columbus, Youngstown, Canton and Norwalk, the sessions at these points being held about once in 6 weeks, instead of once in 2 weeks as in Cleveland. At the last session in Cleveland, 35 dealers were represented, and these, together with the representatives from our own organization, made the attendance 225.

These sessions do not consist merely of talks. We tear down and rebuild rear axles, showing those in attendance how to adjust pinions and bevel-rings properly and emphasizing the results of bad adjustment by displaying samples of what happens to the ring-gear and pinion.

Tool-equipment night is a very interesting session, at which we not only display the tools but explain their uses. We broach and ream out bushings and show what should be done when a reamer becomes plugged or jammed. Many special tools that we have devised to take care of or to speed-up special work are shown and demonstrated at this session. At the last tool session, some 200 tools were on display and afterward a great many orders came in from dealers for various tools that had been demonstrated.

Course of Training

In training the men for the repair department, we start them in the new-car department. Their first job is the oiling and greasing of new cars, an operation that should not be treated lightly. One can learn considerable about oiling and greasing; just why light oil is used in one place, heavy oil in another and grease in still another. Friction of metals is a deep study. If a young man begins to ask questions about lubrication, he certainly can keep one busy. The young men are taught to apply extra equipment, such as bumpers and tire carriers, then stop-lights, driving-lights and the like. In other words, they learn to become handy with wrenches, do the work neatly and at the same time obtain some idea of electrical work by applying electrical equipment. Finally, they are instructed in the cleaning of spark-plugs and the adjusting of valves, brakes and carbureters. The boys are under the constant supervision of one of the best mechanics in our organization.

What happens to a young man at this point of his course is very important. He will either become very much interested or disinterested; in other words, he will get a good or a bad start. Besides being closely supervised, the boys in the new-car department are called together twice a week by the foreman to ascertain just how they are getting along; to find out whether their interest is being maintained and to be given special instruction.

The apprentices are transferred from the new-car department to the toolroom, and from the toolroom in turn to the engine department, to the general repair department, then to the electrical department and, finally, to the inspection and testing department. From there they are transferred back to the department for which they seem best fitted or, in some cases, are retained in the inspection and testing department. The training

that these young men receive in the new-car department is very beneficial and obviates the necessity for the general repair and engine departments' taking the raw edges off. In other words, these two departments do not have to break-in absolutely raw material, but they do continue to maintain very close supervision over the young men. It takes about a year in either of these departments for the young men to become proficient, after which they spend considerable time in the electrical department and finish in the inspection and testing department. The training covers a period of 2 years and 9 months.

Selection of Applicants

Care should be exercised in the hiring of young men. Each one should be questioned closely; he should be "sold" on the industry. The applicant should at least know the elements of mathematics.

In the service department we shall continue to experience some problems that have been present for some time, that is, lack of young men to carry on the work during the peak loads of the summer months. This shortage in the past in some localities has brought on competitive bidding for labor, which has boosted the cost of labor out of all proportion, and either has forced up the cost of repairwork or has caused the dealer to lose money. Still, we have continued year after year, doing very little in the industry as a whole to wipe out this condition.

More thoroughly trained men are greatly needed in this industry. More men are needed who can do the work satisfactorily, who can meet an owner, diagnose a trouble existing in a car and explain the proper method of correcting it.

We should also retain capable men in our organization who may later be called upon to direct one or more departments; the training that a mechanic receives is reflected in the character and the quality of his work. Such men are confident, as they have knowledge that gives confidence and inspires it in all they meet.

When their courses are completed, those young men or boys who have been trained for a specific trade, very easily fit into the organization that has trained them.

Advantages of Apprenticeship System

Through an apprentice system, the character, the personality and the individual ability of each boy are known from early manhood; and it is not difficult to determine just where they will fit in. A carefully planned apprentice system allows the manager of an organization practically to control, guide and advise a young man during his apprenticeship; thus the management can train and prepare men for supervisory positions.

TABLE 1—WAGE SCALE FOR APPRENTICES

	Length of Course, Months	Rate per Hour, Cents						
Period		1	2	3	4	5	6	
Months of Course		1–6	7	8–13	14–19	20–24	25–33	
Department								
New Car	6	25.0						
Toolroom	1		25.0					
Engine	12			27.5	30.0			
General Repair	12					32.5	35.0	
Electrical	1						37.5	
Inspection and Testing	1						37.5	
Total	33							50.0[a]

[a] Mechanics' rate paid upon completion of course.

Organizations that do not have a system for training mechanics are compelled, in many instances, to seek men of supervisory capacity outside. An organization employing an outside man usually accepts him on the recommendation of someone, possibly a friend, who in good faith, so far as friendship goes, wishes to place the applicant with a live company. A person coming into an organization in a supervisory capacity must win his spurs with that particular organization. He must have character, personality, ability, capability. If he has any of these qualifications and is accepted by the organization and retained by his seniors, he must then be trained and fitted into the organization and learn its peculiar needs. This is far more expensive than training a man by some form of apprenticeship system.

Apprentices should not be started before they are 17 years of age, nor after 25. Boys between these ages are receptive, usually eager to learn and, as a consequence, very much interested in obtaining the full benefits of the instruction and schooling.

Qualifications of Apprentices

In selecting apprentices, great care should be exercised in getting the right kind of young men, so that when the course has been completed you will have the best men. Consideration should be given, therefore, to family connections, education, companions and habits. Whenever possible, an apprentice should be a son of a tried and true employe. Then you know the family connection; and the father, even though he does not have direct supervision during working hours, has indirect supervision outside of shop time, which, more or less, controls the education, companions and habits of the apprentice. This is an important factor.

In perfecting an apprenticeship system that will improve with age, every opportunity should be given to the boys at all times, and great interest should be manifested in them. This interest should not lag for an instant; for, if it does, the confidence of the young man may break-down. Considerable pride should be taken in young boys, more than in any other class of labor in the organization.

The percentage of apprentices is usually based on the number of men employed. The ratio, in an organization such as ours, should be about 1 to 10. The matter of percentage is important, as no one department should be overcrowded.

A schedule of apprenticeship, setting forth the number of months spent in each department and the rate of pay, as an apprentice travels through our organization, is shown in Table 1.

Apprentices working on production receive full payment at the prevailing prices.

The earnings of apprentices, when working with a mechanic on a production basis, are paid by ratio and proportion, in accordance with the prevailing rates.

Nothing that has been applied to the maintenance division of the automotive industry is new. Many things have been taken from other lines of industry and have been applied to it, for instance, the piecework and flat-rate systems. The apprentice system is not new by any means. Railroad and contract shops have used it for years for developing their men.

Apparently, it is well to check one another occasionally, to find out the new things that are being done; and, occasionally, it is also well to look outside of our chosen field entirely for the many good things from other industries that can be transplanted into the automotive industry and made to work well.

Oil-Flow in Complete Journal Bearings

By D. P. Barnard, 4th[1]

Semi-Annual Meeting Paper *Illustrated with* Diagrams and Chart

ABSTRACT

General laws governing the rate of flow of oil through complete journal bearings are developed in the paper. These laws are based on the assumption that axial flow obeys Poiseuille's Law and is, therefore, a function of the bearing load. Dimensional reasoning indicates that the volumetric efficiency of a bearing considered as a pump is given by an equation of a form in which efficiency equals a function of the viscosity times the rubbing speed divided by the bearing load, the length divided by the clearance and the length divided by the diameter. Experimental evidence is presented which substantiates this point of view.

The general relation of rubbing speed to heat generation and oil-flow is discussed for the purpose of indicating a possible solution of certain high-speed-bearing problems. A plain bearing is, in effect, a pump in which the flow of a viscous lubricant through a passage of varying area develops a pressure sufficient to sustain the imposed load. Oil-flow in the direction of the axis of such a bearing is due to two causes: Oil-film pressure developed to support the bearing load and oil-feed pressure. The oil-flow due to the first of these causes, or the efficiency of the bearing as a pump, is the important factor. The influence of both sources of pressure are considered separately, and the seven conclusions reached are stated.

The rate of flow of lubricating oil through a bearing is a very important factor in bearing design and performance. This is especially true in the case of high-duty bearings such as are used in automotive engines, steam turbines and certain classes of electrical machinery. The quantity of frictional heat developed in such bearings is large and, frequently, the area of metallic surface available for dissipation of this heat is relatively small. Under such circumstances, it is necessary that as large a portion of this frictional heat as possible be carried away by the oil in which it is developed, and that it never be allowed to reach the metallic surfaces. It is the purpose of this paper to outline the laws governing the rate of oil-flow through complete journal bearings in which the motion is unidirectional.

The fact is well established that, to operate successfully, any high-speed bearing must be lubricated by a fluid film. Under this condition the variables controlling bearing behavior, apart from such details of construction as composition of the surfaces, oil-grooving and the like, are as given in Table 1.

TABLE 1—FACTORS CONTROLLING BEARING PERFORMANCE

Factor	Notation	Dimensions
Absolute Oil Viscosity, centipoises	Z	$ML^{-1}T^{-1}$
Absolute Oil Viscosity, poises	μ	$ML^{-1}T^{-1}$
Rubbing Speed, ft. per min.	$(\pi dN)/12=U$	LT^{-1}
Bearing Load, nominal	P	$ML^{-1}T^{-2}$
Diameter of Bearing, in.	d	L
Length of Bearing, in.	l	L
Diametric Clearance, in.	c	L
Coefficient of Friction	f	O
Velocity of Oil in Film	u	LT^{-1}
Distance Measured in Direction of Motion	x	L
Distance Measured Normal to Motion	y	L
Film Thickness	h	L
Heat Generated in Unit Time	Q	$MLT^{-2}LT^{-1}$

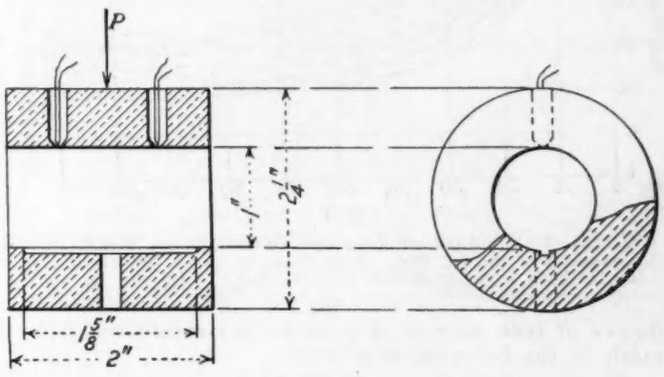

Fig. 1—Experimental Bearing

This Bearing Is Made of Bronze and Supported on a Hardened Journal. The Bearing Load P Was Directed Downward, as Indicated. The Clearance Was Varied by Substituting a Journal of a Different Diameter

A plain bearing is, in effect, a pump in which the flow of a viscous lubricant through a passage of varying area develops a pressure sufficient to sustain the imposed load. Oil-flow in the direction of the axis of such a bearing is due to two causes: Oil-film pressure developed to support the bearing load, and oil-feed pressure. The item of primary interest is the oil-flow due to the first of these causes; in other words, the important thing is the efficiency of the bearing as a pump. Therefore, it is necessary that the relation of oil-flow to pressure due to motion in the oil-film be studied thoroughly. On the other hand, it is a recognized fact that oil-feed pressure is an important factor in bearing performance. The in-

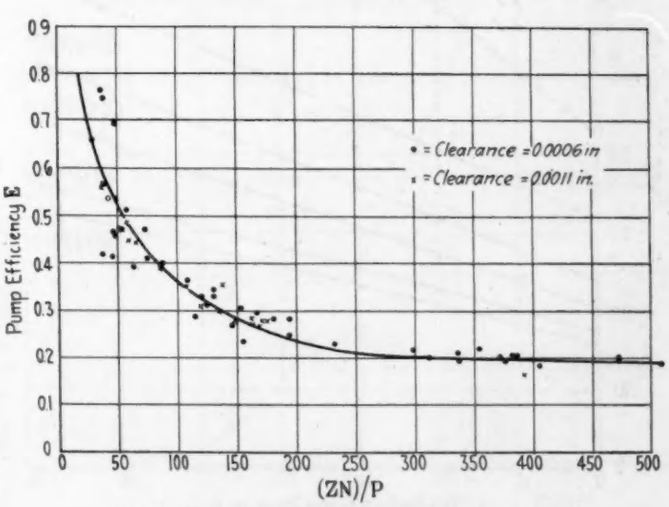

Fig. 2—Experimental Oil-Feed-Pressure Data

For the Low Oil-Feed Pressure, 10 Lb. per Sq. In., a Distinct Curve Having the Same General Form as That for the High Oil-Feed Pressure, 70 Lb. per Sq. In., Was Obtained

[1] M.S.A.E.—Research engineer, Standard Oil Co. of Indiana, Whiting, Ind.

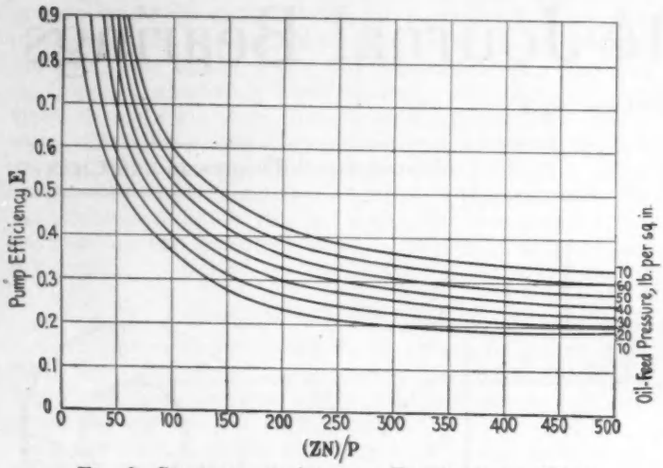

FIG. 3—SUMMARY OF ALL THE EXPERIMENTAL WORK
Observations of the Oil Flow Were Made at 10-Lb. Intervals over the Oil-Feed Pressure Range of from 10 to 70 Lb. per Sq. In.

fluence of both sources of pressure are considered separately in the following discussion.

FLOW DUE TO PRESSURE DEVELOPED IN THE FILM

In a properly lubricated bearing the clearance space is usually completely filled with oil, and a journal revolving in such a bearing drags with it a certain amount of the lubricant. If, at the same time, the journal supports a load, then it must be displaced toward the surface of the bearing, and considerable pressures must be developed in the constricted portions of the film. These pressures result from the force required to drag the oil through the wedge-shaped clearance-space, and vary from point to point throughout the film. The resultant of all such pressures acting on the surface of the bearing must be equal to the imposed bearing, or journal, load and can therefore be regarded as a function of that load.

As the motion of the journal tends to carry oil in the direction of rotation only, end-leakage must be due solely to the pressure in the film. Furthermore, the clearance space is so narrow that all oil-flow within it must be substantially laminar. This is especially true of the axial component of flow. Therefore, end-flow must conform to Poiseuille's Law,[2] which can be stated as follows, and in which flux means volume per unit time

$$\text{Flux} = K\triangle p a^2/\mu l \qquad (1)$$

In equation (1) we have $\triangle p$ representing the pressure drop between the two points under consideration; a is the area of path of flow; l is the length of this path; and μ is the viscosity of the fluid. Arranging the various bearing factors in this manner gives the relation

$$\text{Rate of Flow} = \Phi\,[P(dc)^2/Zl] \qquad (2)$$

In equation (2), Φ indicates that the effective driving-pressure is a function of the bearing load. The volumetric efficiency of a bearing as a pump is expressed, therefore, as follows:

$$\text{Efficiency, } E = \frac{\text{Oil Flow}}{\text{Volume Displaced}} = \frac{\frac{\Phi P(dc)^2}{Zl}}{\frac{\pi N dcl}{2}} = \left(\frac{P}{ZN}\right)^{\alpha}\left(\frac{d}{l}\right)^{\beta}\left(\frac{c}{l}\right)^{\gamma} \qquad (3)$$

The characters α, β and γ indicate that E is a function of the variables grouped as shown. Experimental data should be correlated in accordance with this form. However, to facilitate the plotting of results, it is better to consider E as an inverse function of $(ZN)/P$ rather than the direct function indicated. This avoids the inconvenience of dealing with large numbers when the speed or viscosity is small. The experimental data presented in the following charts have been plotted in this manner. The range covered by these measurements is indicated in Table 2.

[2] See Hydrodynamics, by Horace Lamb, p. 554.

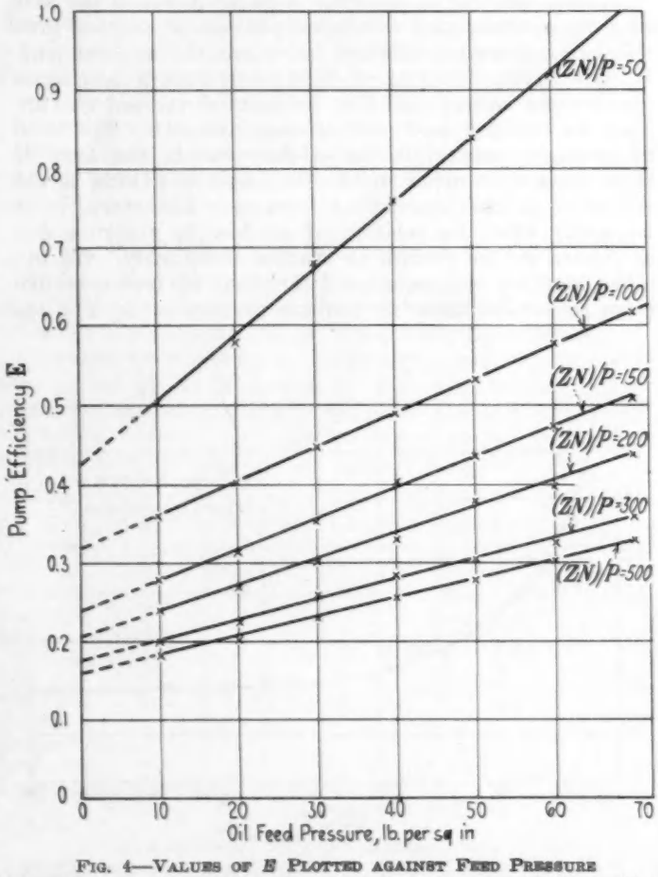

FIG. 4—VALUES OF E PLOTTED AGAINST FEED PRESSURE
The Data Are Presented for Several Values of $(ZN)/P$. Extrapolation of the Lines to Zero Feed-Pressure Gives the True Pumping Efficiency of the Bearing

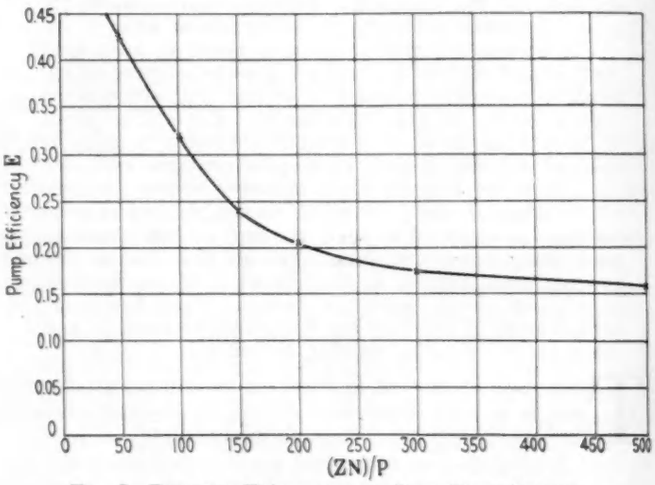

FIG. 5—PUMPING EFFICIENCY AT ZERO FEED-PRESSURE
The Curve for E Shown Was Obtained by Extrapolation of the Lines in Fig. 4 to Zero Feed-Pressure

METHODS USED

In all these experiments, the rate of flow was measured by feeding oil to the bearing from a large burette,

TABLE 2—RANGE COVERED BY OIL-FLOW MEASUREMENTS

Factor	Minimum	Maximum
Z	12.5	43.5
N	200	2,000
P	41	271
d	1	...
l	2	...
c	0.0006	0.0011
Oil-Flow, cu. in. per min.	0.0750	3.0000

and the indicated feed-pressure was obtained by compressed air. A closed-end mercury manometer was used to measure pressure, the values given being those existing at the level of the bearing. The flow was recorded for intervals varying from 5 min. to 30 min. depending on the rate. Oil-film temperatures were measured by a thermocouple mounted with the junction exposed to the load-carrying portion of the film. No attempt was made to measure friction during these tests. The bearing used was of bronze and was supported on a hardened journal, the bearing load being directed downward as indicated in Fig. 1. The clearance was varied by substituting a journal of different diameter.

Figs. 2 and 3 show the experimental data plotted in the form, E versus $(ZN)/P$ for the oil-feed pressures used, a distinct curve of the same general form being obtained for each oil-feed pressure. As an example, the data for 10 lb. per sq. in. oil-feed pressure are plotted in Fig. 2 in accordance with the laws just developed. The curves in Fig. 3 resulted from data obtained by observations of the oil flow made at 10-lb. intervals over the range from 10 to 70 lb. per sq. in. oil-feed pressure. The drop in pumping efficiency with increasing values of $(ZN)/P$ is exactly in accordance with that which would be expected as, under these conditions, the journal occupies a more nearly central position and the tendency is for the oil to follow more closely the direction of journal motion.

As no tendency for the values of E at different clearances to separate is apparent, it must be concluded that changes in this factor, while influencing directly the actual amount of oil flowing, have little or no effect on pumping efficiency. Furthermore, as it would ordinarily

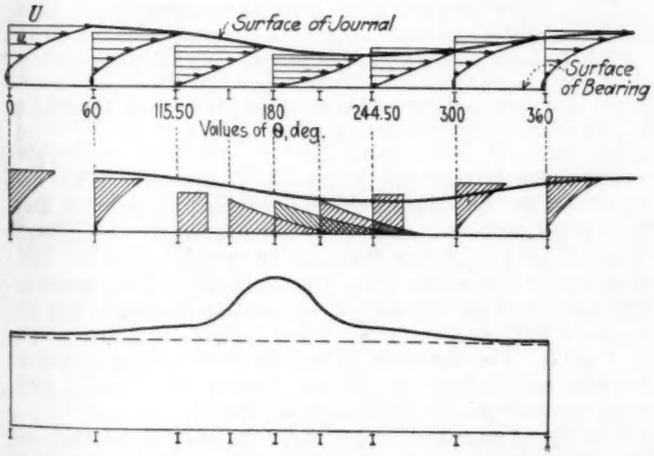

FIG. 6—INCREASE IN RATE OF HEAT GENERATION DUE TO JOURNAL DISPLACEMENT
This Is for the Case in Which $e=0.3$. The Area of the Lowest Diagram Gives the Increase in Heat Generation Due to Displacement for an Entire Bearing of Unit Length

seem probable that the ratio of clearance to length should be of greater influence than that of diameter to length, it is very likely that this latter factor exerts a minor effect.

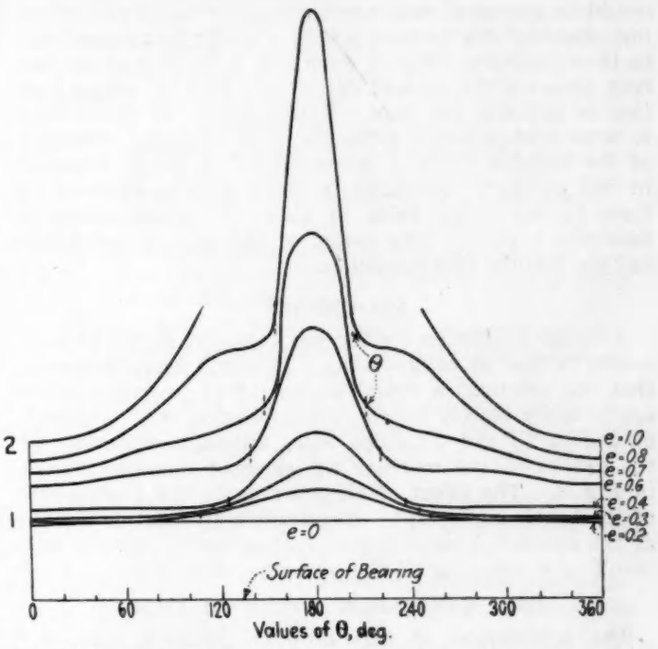

FIG. 7—OTHER CURVES OF INCREASE IN THE HEAT-GENERATION RATE
These Curves Are Similar to the Curves in Fig. 6, but for Other Values of e

EFFECT OF OIL-FEED PRESSURE

Due to the fact that a part of the flow was due to oil-feed pressure, the values for E recorded in these charts are not true pumping efficiencies. Comparisons should be made rather on the basis of the actual pumping-ability of the bearing; that is, under conditions of no oil-feed pressure. Unfortunately, no measurements were made under these conditions. However, it should

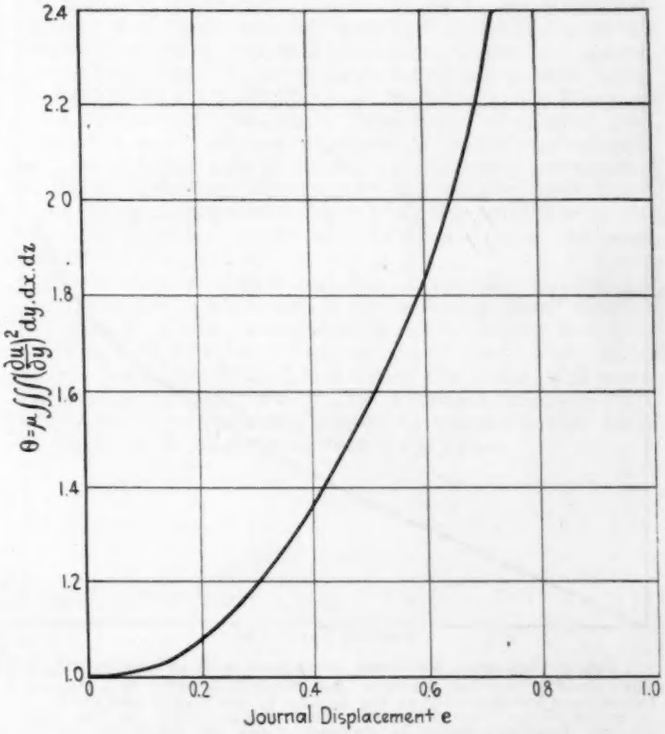

FIG. 8—EFFECTS OF OIL-FILM CONSTRICTION
The Increase in the Rate of Heat Generation for the Entire Bearing as the Film Becomes More and More Constricted Is Clearly Shown

be possible to estimate such values fairly closely, as it would be expected that any increase in apparent pumping efficiency due to feed pressure would be proportional to that pressure. Fig. 4, in which E is plotted against feed pressure for several values of $(ZN)/P$, shows that this is actually the case. Extrapolation of these lines to zero feed-pressure gives the true pumping efficiency of the bearing. Fig. 5 gives the curve for E obtained in this manner. Obviously, a break is to be expected in these curves at the value of $(ZN)/P$ corresponding to fluid-film rupture. The range of the experimental data did not include this condition.

Oil-Grooves

Another important factor not included in the experiments is that of oil-grooving. It would seem, however, that the efficiencies found at zero feed pressure would apply fairly closely to any plain bearing with a simple oil-groove in the unloaded side, although widening of the groove should increase the slope of the lines shown in Fig. 4. The effect of oil-grooving in the loaded side of the bearing is open to considerable speculation. I am of the opinion, however, that such grooving usually will result in a lowering of the pumping efficiency.

Heat Generation in the Oil-Film

The seriousness of this drop in pumping efficiency with increasing values of $(ZN)/P$ in a bearing is apparent from a consideration of the manner in which frictional heat is generated in an oil-film. The theoretical work of Reynolds[3], Sommerfeld[4] and Harrison[5] is confined to the hypothetical case of bearings in which endwise flow does not occur. Actually, of course, this condition is never realized; but the relations established serve to give a general idea of the behavior of bearings of practical construction.

In the case of a bearing in which no end-losses occur, the velocity at any point in the oil-film[6] is given by

$$u = U\left[\frac{h-y}{u} + 3\,\frac{(y^2-hy)\,(h-h_o)}{h^3}\right] \qquad (4)$$

In equation (4)

$$h = c\,(1 + e\cos\Theta) \qquad (5)$$

$$h_o = c\,(1 + e\cos\Theta_o) \qquad (6)$$

$$\cos\Theta_o = -3\,e/(2 + e^2) \qquad (7)$$

The angle Θ is measured in the direction of rotation from the point of maximum film-thickness, and Θ_o corresponds to the points of maximum and minimum film-pressures. This velocity distribution through the oil-film is illustrated by the vector diagram at the top of Fig. 6 for the particular case in which $e = 0.3$. U and c have been arbitrarily assigned the value of unity.

Generation of Frictional Heat

Frictional heat is generated by virtue of the "slipping" of imaginary planes of the fluid over each other. In the case under consideration motion occurs in the direction of journal rotation only. The rate at which heat is generated at any point in such a film is proportional to the square of the velocity gradient at that point[7], that is

$$\frac{dQ}{dy} = \mu\left(\frac{\partial u}{\partial y}\right)^2 \qquad (8)$$

The relation given by equation (8) is illustrated by the middle vector diagram of Fig. 6. The areas under the curves in this diagram represent the total amount of heat generated in the film at the particular point. This can be obtained more easily by direct integration as indicated in the operation

$$Q = \mu\int\left(\frac{\partial u}{\partial y}\right)^2 dy \qquad (9)$$

$$= \mu U^2\left[\frac{4h^2 - 6hh_o + 3h_o^2}{h^3}\right] \qquad (10)$$

Upon reduction to polar coordinates, equation (10) becomes

$$Q = \mu\,\frac{(\pi dN)^2}{c} \times \left[\frac{1 + 2\,e\cos\Theta - 6\,e^2\cos\Theta\cos\Theta_o + e^2\,(4\cos^2\Theta + 3\cos^2\Theta_o)}{(1 + e\cos\Theta)^3}\right] \qquad (11)$$

The term within the brackets of equation (11) determines the increase in the rate of heat generation due to journal displacement. It is illustrated by the lowest diagram in Fig. 6 for the case in which $e = 0.3$. The area under this curve gives the increase in heat generation due to displacement for an entire bearing of unit length. Similar curves for other values of e are given in Fig. 7. The increase in the rate of heat generation for the entire bearing, as the film becomes more and more constricted, is illustrated by Fig. 8.

The foregoing curves all serve to emphasize the influence of speed on the amount of heat generated in a bearing. Other things being equal, the rate of generation increases with the square of the speed. Under conditions of high journal eccentricity, heat generation may not increase quite so rapidly as the square of the speed on account of the fact that increasing $(ZN)/P$ tends to decrease e and, therefore, the bracketed term of equation (11). At the lower values of e, however, the

[3] See Notes on the Theory of Lubrication, by O. Reynolds, *Philosophical Magazine*, series 6, vol. 35, p. 1.

[4] See Hydrodynamic Theory of Friction, by A. Sommerfeld, *Zeitschrift für Mathematik und Physik*, vol. 50, p. 97.

[5] See Hydrodynamic Theory of Lubrication, by W. T. Harrison, *Transactions of the Cambridge Philosophical Society*, vol. 22, p. 39.

[6] See Hydrodynamics, by Horace Lamb, p. 549.

[7] See Hydrodynamics, by Horace Lamb, p. 549.

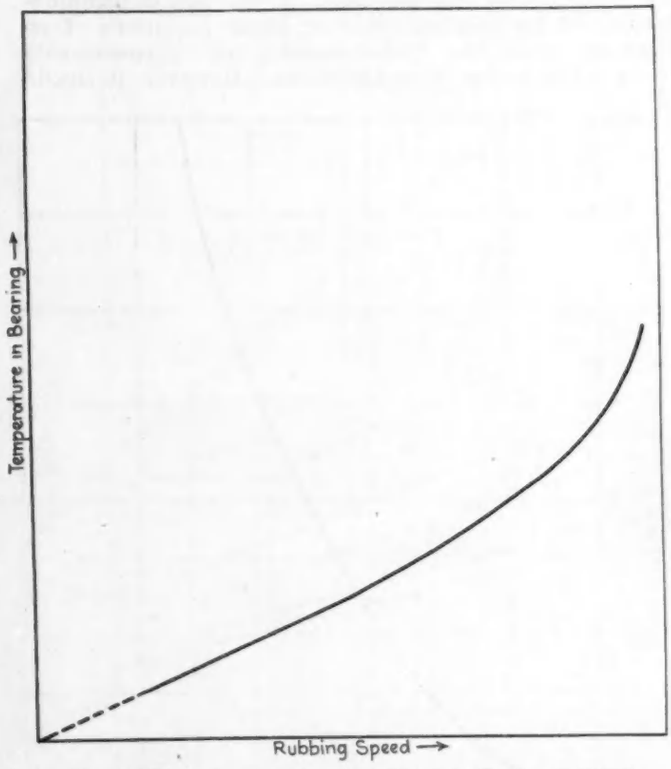

Fig. 9—Relation Between Temperature Rise and Speed

The Curve Brings Out the Fact That Heat Generation in a Bearing Increases Approximately as the Square of the Speed, and Oil-Flow as Some Power Less Than the First Power. This Implies That All the Frictional Heat Is Carried Away by the Flow of Oil through the Bearing, a Condition Which Is Not So Far Removed from Fact in the Case of the Main Bearings in High-Speed Internal-Combustion Engines and Steam Turbines

decrease in this term is comparatively small and the rate of generation follows very closely the law of the square of the speed.

From the foregoing discussion, it is evident that increasing the rubbing speed of a bearing in the ordinary operating range serves: First, to increase the amount of heat generated at a rate almost proportional to the square of the speed; and second, to decrease the pumping efficiency of the bearing. In other words, heat generation in a bearing increases approximately as the square of the speed, and oil-flow, as some power less than the first. This gives rise to a relation between temperature rise and speed such as is typified in Fig. 9. This implies, of course, that all the frictional heat is carried away by the flow of oil through the bearing, a condition which is not so far removed from fact in the case of some of the main bearings in high-speed internal-combustion engines and steam turbines. Here the area of metallic surface effective in dissipating heat is very severely limited and is usually exposed to fairly high temperatures. It is readily possible that this may account for the sometimes "unexplained" bearing failures such as are prone to occur in turbines and in certain classes of electrical machinery.

Therefore, high-duty bearings should be constructed so as to enable the oil to carry away as much of the frictional heat as possible. When this cannot be realized to a sufficient extent, recourse must be taken to metallic conduction.

The foregoing discussion is summarized, briefly, as follows:

(1) A complete journal bearing can be considered as an oil-pump in which the pressure developed is utilized to support the imposed load and to induce a flow of oil through the bearing

(2) The volumetric efficiency of a bearing as a pump is a function of the factors governing bearing operation grouped in the following dimensionless order (ZN/P), (l/c), (l/d). The term ZN/P apparently exerts the predominating influence

(3) Oil-feed pressure serves to increase the total flow through a bearing by an amount proportional to the feed pressure

(4) The rate of heat generation increases approximately as the square of the speed and oil-flow, as some power less than the first

(5) Unless heat dissipation by metallic conduction be very efficient, the temperature rise in a bearing will increase at a rate greater than the first power of the speed

(6) Bearing research should include an effort to increase pumping efficiency apart from that obtained by raising oil-feed pressure

(7) Efficiency of heat transfer by metallic conduction should be studied thoroughly in the case of high-duty bearings

I wish to express my appreciation to the department of chemical engineering at the Massachusetts Institute of Technology for permission to publish the data on oil-flow and to C. W. Stose, who conducted the experimental work.

THE PROSPERITY OF FRANCE

THE prosperity of France means the prosperity of her farmers. In 1921 the population actively engaged in agriculture numbered 21,000,000 out of a total population of 39,200,000; that is, 53.6 per cent. The proportion now is undoubtedly greater, owing to the return of more agriculturists to the devastated regions. The vast majority of these people are independent land-owners, the proportion being 5,219,464 land-owners to 3,297,766 hired workers. The consequence of this, of course, is that agricultural France is divided up into millions of minute parcels. In fact, 4,500,000 out of the 5,300,000 holdings are composed of 24 acres and less. More than 2,000,000 have less than 2 acres. Incidentally, this is a fact that must not be forgotten in calling for increased taxation of the peasant. The man supporting a family of four people on 2 acres cannot afford to set aside very much for the national treasury.

The countryside everywhere teems with evidence of the fat years in which the peasant has been living since the war. Brittany has always been considered one of the poorest of the French provinces. And yet, if the present-day visitor to any of the hamlets along the coast inspects the outfits that are drawn up before the cafes on a Sunday evening, he will find smart lacquered carts drawn by horses in polished harness, and automobiles, all new, and all belonging to the peasants who have been selling potatoes across the Channel for the last 5 years at an exchange very much in their favor. Scarcely an unprofitable farm can be found in the Province. Land values have jumped to three times what they were before the war. Brittany, of course, is the extreme example of prosperity, but only in degree is it different from the rest of France. Go into the center of the country, where they raise turkeys and other domestic fowl, and learn how profitable they have found it to cater to the market on the other side of the Channel.

Whatever may be the hesitation of the national finances, the individual Frenchman is not suffering from want or hard times. His capacity for work and his ability to squeeze every centime of value out of a sou are beyond belief. After all the bewailing of the last 6 years, one learns with something like astonishment of the relentless intensity with which the Frenchman has labored to put his ruined house in order.—J. R. Ellington in *New York Times*.

Vol. XVII August, 1925 No. 2

Friction Transmission for Automobiles

By C. A. TRASK[1]

INDIANA SECTION PAPER *Illustrated with* DRAWINGS AND PHOTOGRAPHS

ABSTRACT

ALTHOUGH few cars with friction transmissions are produced today, it is in no wise attributable to failure or unsatisfactory performance of the friction drive. Instances of the successful transmission of power by drives without teeth are found in the thousands of pulleys in constant use, locomotive driving wheels on smooth rails, automobile tires on paved roads and the numerous tractors and industrial locomotives in successful operation.

The 1300-mile Glidden Tour in 1913 was won by a team of three friction-driven cars, each finishing with a perfect record. Inasmuch as the friction drive is especially adapted to lightweight cars, a type finding increasing favor with the public, the field of the small car is becoming greater.

The advantages claimed for the friction drive are simplicity of handling, silence, high efficiency, capacity for allowing the full power of the engine to be used under all conditions of grade and road, no clashing of gears when changing, ability of the driver to shift from the high-speed position into reverse with a straight movement of the hand-lever while the car is running and ratio changes so nearly instantaneous that it is seldom necessary to close the throttle when changing.

A MORE satisfactory transmission for automobiles than the disc and spur friction, especially for congested traffic conditions, has, I believe, never been devised. This is especially true when applied to light cars. Thousands of cars with capacities ranging from two to seven passengers have been built with friction transmissions; and the fact that very few cars of this type are being produced today is in no wise attributable to the failure or unsatisfactory performance of this type of transmission.

[1] M.S.A.E.—Equipment efficiency engineer, Rockwood Mfg. Co., Indianapolis.

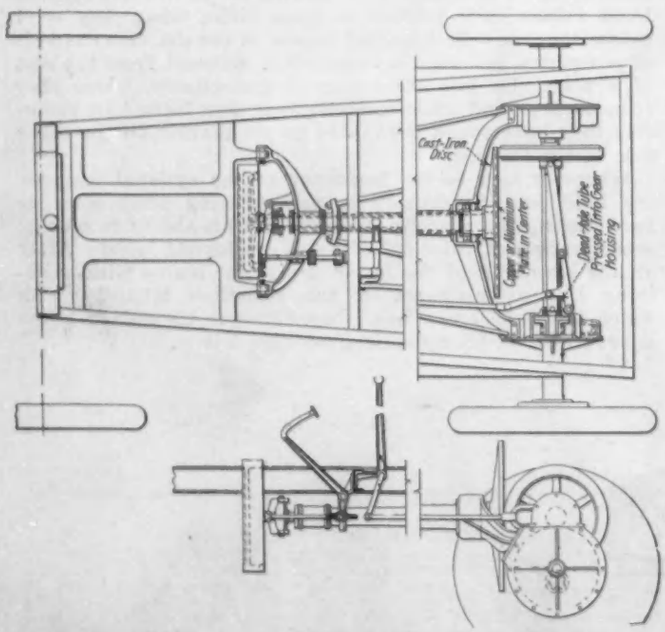

FIG. 1—TRANSMISSION WITH FRICTION-SHAFT DRIVE
This Is Designed To Avoid the Use of a Chain, Formerly One of the Troublesome Features of Friction-Driven Cars

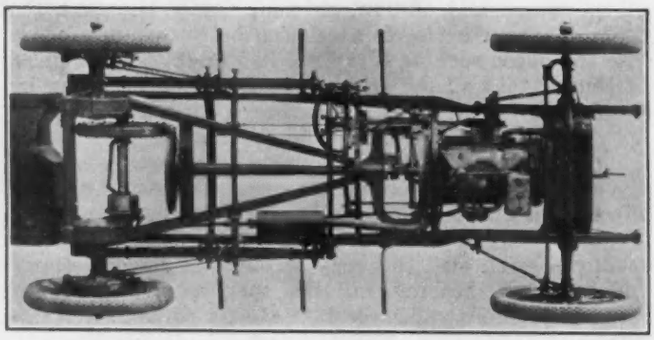

FIG. 2—BOTTOM VIEW OF FRICTION-SHAFT DRIVE SHOWN IN FIG. 1
Operation of a Car Equipped with This Transmission Is Absolutely Silent

"Will the friction surfaces hold?" may be asked. "There are no teeth; the surfaces are smooth." Pulleys have no teeth, yet thousands of belt drives testify to their satisfactory power-transmitting performance. An automobile tire on a paved road is a satisfactory drive; locomotive driving-wheels not only move the engine along the smooth rails but also demonstrate their ability to pull hundreds of tons in addition. With these applications of friction we are all familiar. Thousands of tractors equipped with friction transmissions are pulling gang-plows and other heavy loads. Hundreds of industrial locomotives driven by similar devices are in successful operation.

The 1913 Glidden Tour was run over 1300 miles of unusually rough and hilly roads in Minnesota, North Dakota and Montana in 7 days. This great test was particiated in by the best cars that American skill and experience could produce. The winning team of three friction-driven cars carried off the famous trophy, each car finishing with a perfect record, while many other contestants were penalized and several cars were withdrawn owing to complete breakdowns.

ADAPTABILITY TO LIGHT CARS

I feel that the friction drive is better fitted to handle light cars than cars of large carrying-capacity and, as the motoring public is awakening to the fact that smaller and lighter cars are more desirable, especially for city use, the field for a small car is becoming very great. E. S. Jordan, president of the Jordan Motor Car Co., stated recently that the use of light-weight economical high-speed little cars is increasing rapidly; the cost will be $200 or $300, and each member of the family will own one. Roy Chapin, of Detroit, in a speech before a large gathering of automotive men in New York City during the Automobile Show in January, said that small one or two-passenger cars would be the best solution of the present unbearable traffic and parking conditions

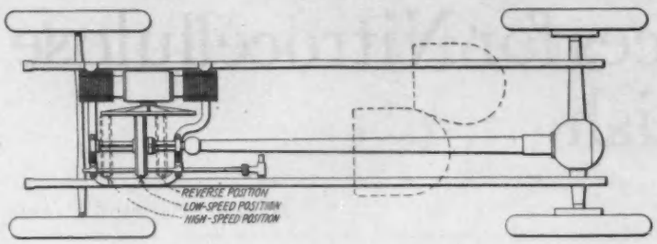

FIG. 3—SIMPLE CYCLE-CAR TRANSMISSION

in the cities; and thousands of motorists are ready to agree with him.

Fig. 1 shows an application of the friction transmission designed to avoid the use of a chain, which, by the way, was one of the troublesome features of the friction-driven cars of 10 or 15 years ago. The engine, a flexible coupling, a yoke, torque tube, disc, spur friction, pinions and gears to the rear axles are shown.

Fig. 2 shows the bottom view of a car equipped with a chainless friction transmission similar to that of Fig. 1. The operation of this car was one of my most pleasing experiences; it is absolutely silent as to transmission. Fig. 3 shows a simple transmission designed for a cycle-car.

With the type of car shown in Fig. 4 and with the discs in high-speed position giving a ratio of about 3 to 1, it would be possible to "caper along" on paved roads well up to the legal speed-limit with the engine running at very moderate speeds; 45 or 50 miles per gal. could easily be obtained.

ADVANTAGES OF FRICTION DRIVE

The handling of the car is so simple, so easily understood and so silent that it appeals to the inexperienced driver as well as to the driver who has handled cars with difficult gear-shifts. No other type of transmission approaches this one in efficiency. No matter what the grade or the road condition is, you always have a transmission ratio that will allow the use of the full power of the engine to the best advantage. No clashing of gears occurs when changing and no gear noise when running. You can go from the high-speed position into reverse with one straight movement of the hand-lever while the car is running; and this is done silently. Ratio changes, after a little practice, are so nearly instantaneous that it is seldom necessary to close the throttle when changing, and you invariably get ahead of the other fellow when the traffic "cop" says "Go."

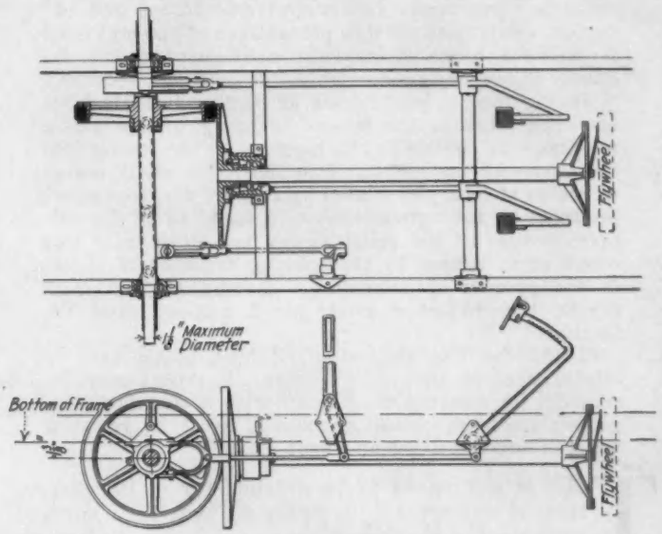

FIG. 4—FRICTION TRANSMISSION UNIT
From 45 to 50 Miles per Gal. of Gasoline Can Easily Be Obtained

LENGTH OF HAUL BY MOTOR TRUCK

IN Connecticut nearly 40 per cent of the total tonnage by truck is moved less than 10 miles and nearly 70 per cent less than 30 miles. The movement that runs to 100 miles and over is largely one of furniture and household goods in which promptness of delivery and the minimum of handling are the controlling elements. In California 25 per cent of the total tonnage by truck is hauled less than 10 miles and 60 per cent less than 30 miles; and the tonnage that is hauled more than 70 miles is less than 20 per cent. The reasons for the greater long-distance movement in California are fairly clear. They are the greater distances between cities and the less complete service afforded by the railroads. In Cook County, Illinois, 24 per cent of the motor-truck movement is less than 10 miles; 75 per cent less than 30 miles; and less than 3 per cent moves a greater distance than 100 miles.

The long truck-haul does not pay and truck operators know it does not. One of the most reputable haulage companies in the United States operated a fleet of 35 trucks averaging 3½ tons capacity between Buffalo and Erie and Erie and Cleveland. The distance is about 100 miles in each case. The rates were based on the railroad tariff; a little more for the low-class commodities, a little less for the high-class, but averaging fairly close to the railroad rates. And, on the basis of a year's operation, with $200,000 gross revenue, the net loss was $14,000.

In Chicago, in 1914, 94 per cent of the milk used in the city was transported by steam railroad, 2 per cent by electric railways and 4 per cent by wagons. Since then the growth of a circle of suburban towns and subdivisions around the city has gradually pushed the dairy farms back beyond a wagon's haul of the city, so that today none of the milk used by the city is delivered to it by wagon. But the motor truck now brings in 32 per cent of the city's supply and the percentage transported by the 26 steam railroads has been reduced to 68 per cent. Electric railway shipments have ceased.

In the Indianapolis market, it has been found that more than 30 per cent of the total receipts of hogs for the year is delivered by truck. Ten years ago such deliveries constituted only 5 per cent of the total receipts. Today within a 50-mile radius of the yards 90 per cent of all hogs raised are moved in by truck.

A popular idea that I feel disposed to deny is that motor trucks are destroying our roads. I do not know why it should need denial, but apparently it does. Look around you. Are the roads getting better or worse? Have we ever before had such fine ones or so many of them? Have we ever before had fewer of them in a state of disrepair? Well, as many motor trucks are now using these roads as there were of all kinds of motor vehicle 10 years ago, but the cost of the roads per ton-mile of traffic is far less now than it was then. This has been accomplished, first, by the really notable improvements that have been made in the design of highway surface; secondly, by the building-up of efficient administrative and engineering organizations; and thirdly, by the greatly increased use, which far exceeds the increase in the cost of the roads.—From an address by Secretary of Agriculture Jardine, before Mid-West Transportation Conference.

Preparation of Surfaces for Nitrocellulose Finish

By JOHN MCGEORGE[1] DETROIT SECTION PAPER

ABSTRACT

TWO points must be watched closely in preparing sheet steel surfaces for the spraying on of nitrocellulose compounds: (*a*) perfect smoothness and (*b*) perfect cleanliness. Extra precautions at the mill must be paid for, hence an inspector must guard against the effects of too much reduction in the price of the sheets.

Among the various causes of surface imperfections are those due to insufficient cropping of the ingot, roughness or defects in the ingot mold, the rolling into the bloom of scale sticking to the ingot, short marks or seams at intervals caused by trapped air, coarseness produced by rolling when too cold, buckling of the surface because of the rolls' having too much belly and rough spots caused by the sticking together of sheets in the process of annealing. Having secured good sheets, the inspector must guard against their ill-treatment.

Cleanliness, like most simple things, is not easy to attain. Grease and other foreign substances must be removed by washing thoroughly with a cleaning compound; then the cleaning material must be removed and the surface dried and kept clean.

THE actual points to be watched for in the inspection of sheet steel, in order to provide a surface suitable for the spraying on of nitrocellulose or pyroxylin compounds in the finishing of automobile bodies and similar work, are few and simple and may be reduced to two: (*a*) a perfectly smooth and (*b*) a perfectly clean surface.

A perfect surface will have neither regular nor irregular depressions, such as come from insufficient cropping of the ingot or bloom to take away the part that contains most of the segregated impurities, or from the trapping of air or gas on the inner surfaces of the ingot molds; or that result from roughness or other defects in the ingot mold and should be chipped out of the ingot, or from the rolling into the bloom of scale sticking to the ingot in the first breaking-down and which also should be chipped out of the bloom.

SEAMS CAUSED BY TRAPPED AIR

A perfect surface will not have short marks or seams at intervals, such as have been noted by R. W. Hunt in a paper[2] read by him in 1914 on the elimination of seams. He notes that small round depressions about 1/16 in. in diameter, probably caused by trapped air, were elongated, after 15 passes, into a fine deep line about ¾ in. long. These marks are sometimes filled with a white powder and are usually about ¼ to ½ in. long. I have found a sheet that had approximately 80 to 100 such lines in a 12 x 12-in. surface that was perfectly smooth to the touch.

An ideal sheet will not have a surface made coarse by rolling when too cold, in an effort to attain a highly glossy surface, and will not have a buckled surface, often caused by the rolls having too much belly, particularly when rolling sheets, in an effort to keep the plates from being thicker at the center.

A perfect surface will not have rough spots that have been produced by the sticking together of the sheets in the process of annealing, and that will occur if the sealing of the annealing boxes, especially near the edges, is defective in any respect.

IMPURITIES

Regarding so-called impurities, such as silicon, phosphorus, manganese and sulphur, Campbell says[3]:

> The composition of steel requires very careful balancing; and this can well be left to the chemist.

Quoting from a research report from Dayton:

> The ingots are rolled into blooms about 8 in. square and cropped from the top end. The amount of cropping depends on the drawing quality of the finished sheet desired.

Again, in the same report, in speaking of the Erichsen test, we find the expression: "To stand forming without pulling coarse."

I have mentioned a few of the things to be guarded against, simply to show that an inspector must watch for the effects of too much reduction in the price of sheets, for all the extra precautions to be taken at the mill, such as the cropping, pickling, washing, annealing, cold rolling, analyzing, shipping and selecting of blooms and sheet bars, must be paid for.

SUBSEQUENT ILL-TREATMENT

Again, having obtained good, I will not say perfect, sheets, the inspector must guard against ill-treatment of them. They must be formed without excessive depressions, such as must be filled with solder; or waves, such as must be filed out. If filing must be done, the files should not be too coarse, should be kept clean, and should not be carelessly used so as to leave deep scratches. If solder is used, care must be taken that the solder is not loose on the feather edges. If waves in the steel are present, they must be carefully dinged out. If the inspector does not catch these things, the painting foreman will, and war will follow. In the use of nitrocellulose paints, the less filling and knifing there is in the first or under coats, the better.

CLEANLINESS

Having an approximately perfect surface, we shall then seek the second point, cleanliness, which is apparently simple but, like most things, not easy to get. In fact, to paraphrase a popular saying: Eternal vigilance is the price of cleanliness. It is attainable by thoroughly washing with one of the many cleaning compounds, the essential point being that all grease shall be removed and all other foreign substances washed away; then, that the cleaning material itself shall be washed away, preferably by alcohol and hot water, and the surface thoroughly dried by clean air or other means and kept clean until the under coats have dried on as base for the nitrocellulose finish.

[1] M.S.A.E.—Consulting engineer, works engineering and maintenance department, Oakland Motor Car Co., Pontiac, Mich.

[2] See *The Iron Age*, Dec. 10, 1914, p. 1334.

[3] See The Manufacture and Properties of Iron and Steel, by H. H. Campbell.

Eye-Bolt Stresses as Determined by Photoelastic Test

By THOMAS H. FROST[1] AND LIEUT. WALTER E. RICHARDS,[2] U. S. A. *Illustrated with* DRAWINGS

ABSTRACT

PRINCIPAL stresses in one type of eye-bolt have been determined in the laboratory of photoelasticity at the Massachusetts Institute of Technology by the photoelastic method. In the test, an eye-bolt, designed in accordance with a method suggested for circular eyes in a course in machine design by the Institute, was made of celluloid 0.25 in. thick, 1 in. wide on either side of the eye, with a 1.405-in. diameter of eye, and a 1.333-in. width of shank. Steel loading-plates were pinned to the broadened end of the shank and a load of 100 lb. was suspended from the bolt, which gave a mean stress of 300 lb. per sq. in. in the shank. Plain polarized light was passed through the celluloid model and the isoclinic lines, or lines of equal inclination of principal stress, were observed and recorded. Two families of lines of principal stress, designated as *P* and *Q* stresses, were determined graphically from these isoclinic lines. The difference in these principal stresses was determined by circularly polarized light, the transparent model being placed in suitable apparatus and loaded, the image on the screen becoming highly colored. These color bands are isochromatic lines that indicate an equal value of difference of the principal *P* and *Q* stresses.

For a complete determination of the stress, it was necessary to record the isochromatic lines and to measure the value of the difference of principal stress at a sufficient number of points in the model. The isoclinic and isochromatic lines, the lines of principal stress and the points at which the value of the difference in principal stresses were measured, are shown in drawings. Values of the principal stress at several sections through the model are plotted.

The test shows that the maximum stress of 862.44 lb. per sq. in. occurs at a section on either side of the eye at the inner boundary 0.115 in. below the line from the center of the eye to the outer boundary of the bolt perpendicular to the axis of the shank. The principal tension and compression stresses per square inch at many points in the model under an applied load of 100 lb. are given in tabular form, in which the *P* and *Q* stresses along the interior boundary and at the sections of maximum stress are also given separately.

Conclusions deduced from the test are (*a*) that, in an eye-bolt of the type tested and bearing on a pin that fills the eye, a maximum stress equal to 2.87 times the mean stress applied to the shank must be expected at the interior boundary of the eye and (*b*) that the type of pin or support used will affect the stress distribution considerably, so that, in subsequent tests, it would be advisable to reduce the pin diameter successively, observing the effect upon the stress.

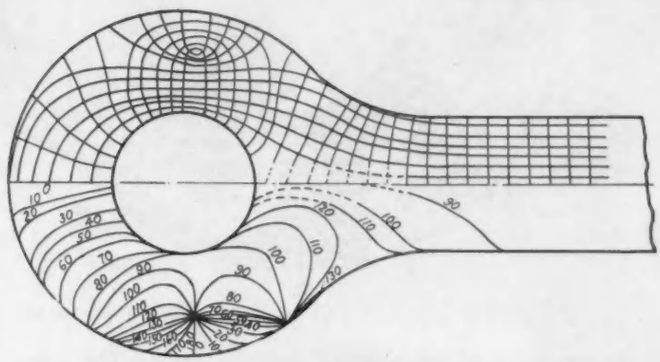

FIG. 2—ISOCLINIC LINES AND PRINCIPAL STRESS LINES SHOWN ON SYMMETRICAL HALVES OF MODEL

The Isoclinic Lines Are Shown in the Upper Half and the Lines of Principal Stress in the Lower Half. The Figures on the Isoclinic Lines Express in Degrees the Angle Made with the Longitudinal Axis of Direction *O*

DETERMINATION of the stresses in eye-bolts by the photoelastic method was begun last year in the laboratory of photoelasticity at the Massachusetts Institute of Technology, Cambridge, Mass. This method has been referred to in THE JOURNAL[3] and has been described in other publications,[4] hence a résumé is not given here but a full exposition can be found in the bibliography referred to in the footnotes. The present thesis was carried out under the direction of Prof. Paul Heymans, of the Institute.

Only one type of eye-bolt has been examined by this method so far but it is hoped that the results obtained will be of sufficient interest to engineers to warrant continuation of this work with other types in an effort to aid in the standardization of the design of eye-bolts. The model of the eye-bolt that was used in these tests was designed in accordance with methods suggested for circular eyes in the course in machine design[5] at the Massachusetts Institute of Technology, which may be summarized as follows:

[1] Instructor, department of physics, Massachusetts Institute of Technology, Cambridge, Mass.

[2] Engineering division, Air Service, McCook Field, Dayton, Ohio.

[3] See THE JOURNAL, December, 1923, p. 497.

[4] See *Bulletin de la Societe Belge des Ingenieurs et des Industriels*, vol. 2, No. 2, 1921; *Transactions of the Society of Mechanical Engineers*, vol. 44, p. 513; *The Tech Engineering News*, June, 1922, p. 80.

[5] See Notes on Machine Design, Massachusetts Institute of Technology, Cambridge, Mass.

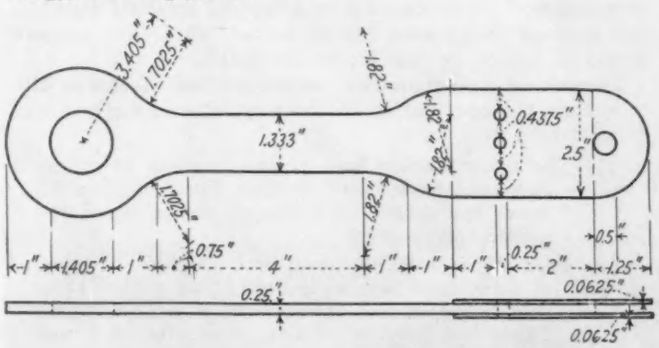

FIG. 1—PLAN OF EYE-BOLT MODEL USED IN THE TEST

This Model Was Made of Celluloid to the Dimensions Shown. A Pair of Steel Loading-Plates, Secured to the Broadened Shank by Pins Passing through a Series of Three Holes, Was Used To Support a Load of 100 Lb.

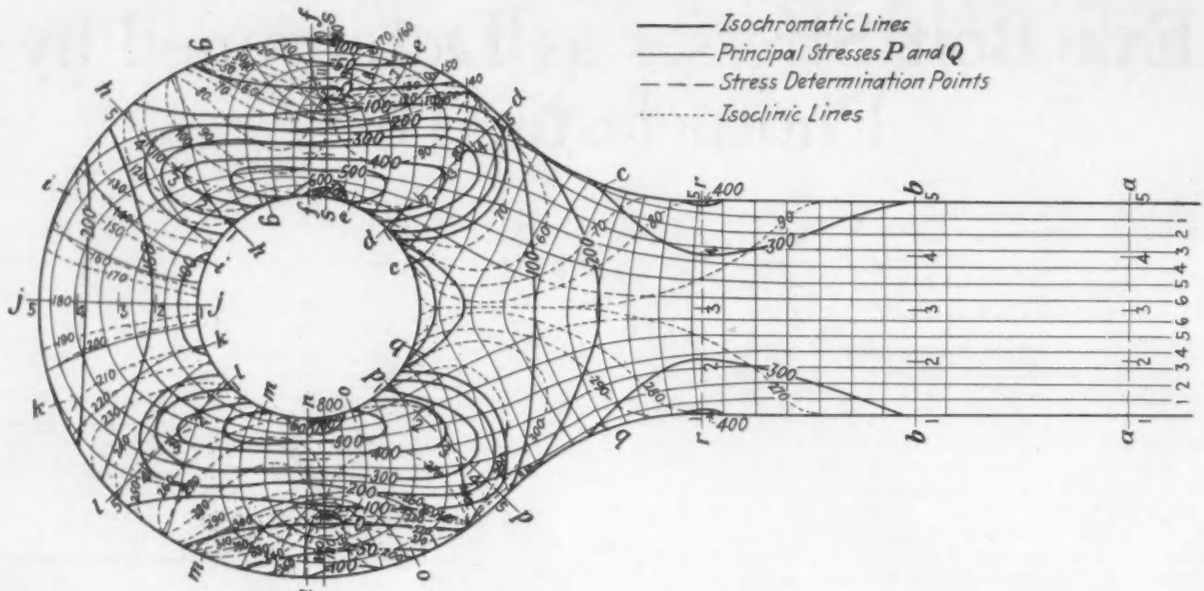

FIG. 3—ISOCLINIC LINES, LINES OF PRINCIPAL STRESS, ISOCHROMATIC LINES AND STRESS-DETERMINATION POINTS SUPERIMPOSED

In eye-bolts of rectangular section, having the same thickness of material A throughout, let C represent the width of the shank. Then

Area of the Shank $= AC$
Total Area through the Eye $= 1.5\ AC$
Area of Each Side of the Eye $= 0.75\ AC$
Width of Material around the Eye $= 0.75\ C$

Furthermore, the width of the shank must be about 95 per cent of the pin diameter.

For convenience in making the stress determinations, it was decided to construct the eye-bolt of celluloid having a thickness of 0.25 in. With this thickness, A= 0.25 in. To follow the foregoing principles of design, it was necessary to decide upon one other dimension, hence the width of the material on either side of the eye was taken as equal to 1 in. Therefore, the width of the shank C = 1/0.75 = 1.333 in. This having been determined, the pin diameter becomes 1.333/0.95 = 1.405 in. Curvature of the section joining the outside of the eye to the shank was made equal to the radius of the outside of the eye, 1.7025 in., as shown in the plan of the model, Fig. 1. To have a uniform distribution of stress in the shank, the shank was made 4 in. long and then widened to 2.5 in., the widening being accomplished in a distance of 2.5 in. by a 1.2-in. radius. Three 0.25-in. holes, equally spaced, were then drilled in the widened portion 1 in. from the beginning of its maximum width to provide for the steel loading-plates with which tension was applied.

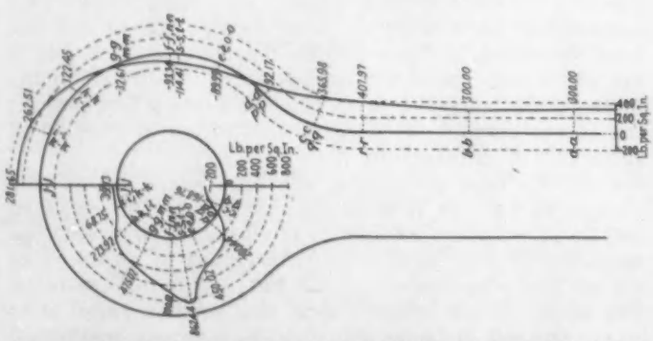

FIG. 4—VALUES OF THE DIFFERENCE OF PRINCIPAL STRESSES ALONG BOUNDARIES OF MODEL AS DETERMINED OPTICALLY
These Values Are Plotted Perpendicularly to the Boundaries, Tension Being Plotted Outward and Compression Inward

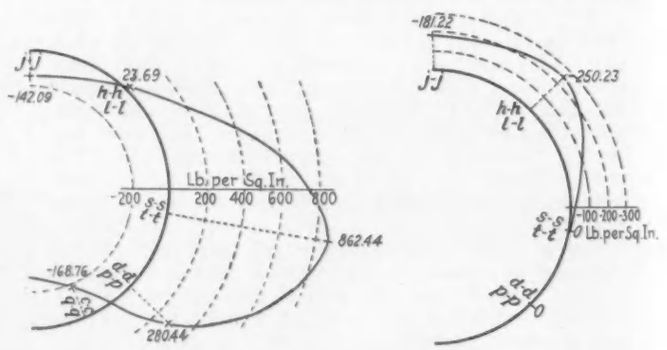

FIG. 5—PRINCIPAL STRESSES ALONG INTERIOR BOUNDARY OF EYE
There Are Two Families of These Stresses. The *P* Stress Is Shown in the Drawing at the Left and the *Q* Stress at the Right. Tension Is Plotted Perpendicularly Outward and Compression Perpendicularly Inward. The Maximum Stress of 862.44 Lb. Occurs at Section *ss* and *tt* on Opposite Sides of the Eye

HOW THE TEST WAS MADE

This model was supported by a pair of steel bars, one passing on either side below the eye and upon which the pin, which completely filled the eye, rested when placed in position. Direct tension was applied by dead weights, 100 lb. load being used for all tests. This gave a mean stress of 300 lb. per sq. in. in the shank.

In making an exhaustive determination of stress distribution, the application of the photoelastic method was divided into four parts:

(1) The model having been placed in plane polarized light and loaded, the isoclinic lines, or lines of equal inclination of principal stress, were observed and recorded

(2) From these isoclinic lines, both families of lines of principal stress were determined graphically, this being a two-dimensional stress problem. These two families of lines are referred to as lines of *P* and *Q* stress, respectively, and are so indicated in Fig. 2, which shows the isoclinic lines and the lines of principal stress on symmetrical halves of the model

(3) The next step was the determination of the difference of the principal stresses by circularly polarized light. When these transparent models are placed in a suitable apparatus and loaded, the image shown on the screen becomes highly colored. The color bands are isochromatic lines that indicate an equal value of difference in the principal stresses

(4) For the complete determination of the stresses it is necessary to record these isochromatic lines as well as to measure, by a compensating method, the value of the difference of principal stress at a sufficient number of points

Fig. 3 shows the isochromatic lines superimposed on the isoclinic lines and the lines of principal stress, and also indicates the points where the values of the difference of the principal stresses were measured. It will be noted that a complete analysis has been made along the interior and the exterior boundaries of the model as well as across eight sections through the eye and two sections through the shank.

The separate values of the two principal stresses at any point in the model could be calculated from the data acquired by the foregoing method, but as the method of calculation[6] is long, only the more interesting results of the test will be given.

Results of the Test

The values of the stresses, as determined for certain sections of the model for an applied load of 100 lb., are given in Table 1, in which the minus sign denotes compression. For the direction of the principal stresses at the different points, see Figs. 2 and 3, in which the lines of principal stress are shown.

The values of the difference of the principal stresses along the boundaries of the model are shown in Fig. 4. These values are plotted perpendicularly to the boundaries, tension being outward and compression inward. It should be kept in mind that in all cases where the boundary is free the value obtained for the difference of

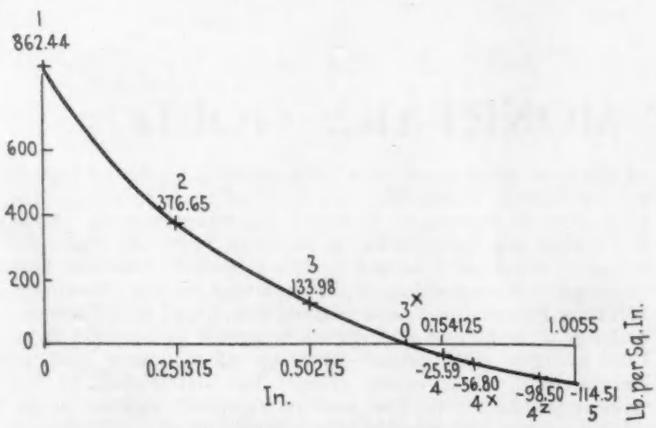

Fig. 6—Values of P Stress Across Sections ss and tt

principal stresses becomes the value for the one existing principal stress that is tangent to the free boundary, since the other is zero, there being no outside applied load. Therefore, the values of $(P\text{-}Q)$ shown for the exterior boundary are the values of the only existing stress P. The plug bears on the interior boundary between sections jj and ss (Fig. 3), so the plotted values of

[6] See *Engineering*, Oct. 19, 1923, p. 511.

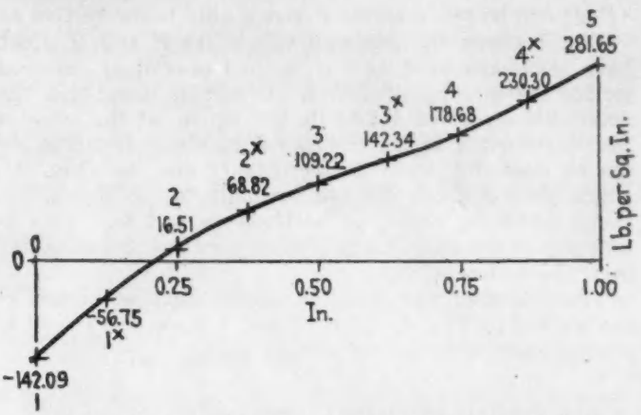

Fig. 7—Values of P Stress Across Section jj in Fig. 3

Table 1—Stresses in Eye-Bolt Model under 100-lb. Load

Point	P Stress along Interior Boundary, Lb. per Sq. In.	P Stress along Exterior Boundary, Lb. per Sq. In.
a	.....	300.00
b	.....	300.00
c and q	—168.76[a]	365.98
d and p	280.44	92.17
e and o	450.02	—89.99[a]
s and t	862.44	—114.41[a]
f and n	700.02	—93.34[a]
g and m	485.02	—32.61[a]
h and l	273.92	122.45
i and k	68.75	262.51
j	39.13	281.65

	P Stress = Lb. per Sq. In.	Q Stress = Lb. per Sq. In.
Principal Stresses along Interior Boundary		
c and a	—168.76[a]	0.00
d and p	280.44	0.00
s and t	862.44	0.00
h and l	23.69	—250.23[a]
j	—142.09[a]	—181.22[a]
Principal Stresses across Sections ss and tt		
1	862.44	0.00
2	376.65	0.00
3	133.98	0.00
3^x	0.00	0.00
4	—25.59[a]	18.98
4^x	—56.80[a]	13.20
4^z	—98.50[a]	2.50
5	—114.51[a]	0.00
Principal Stresses across Section jj		
1	—142.09[a]	—181.22[a]
1^x	—56.75[a]	—159.75[a]
2	16.51	—130.44[a]
2^x	68.82	—101.18[a]
3	109.22	—74.46[a]
3^x	142.34	—50.66[a]
4	178.68	—29.49[a]
4^x	230.30	—9.70[a]
5	281.65	0.00

[a] The minus sign denotes compression.

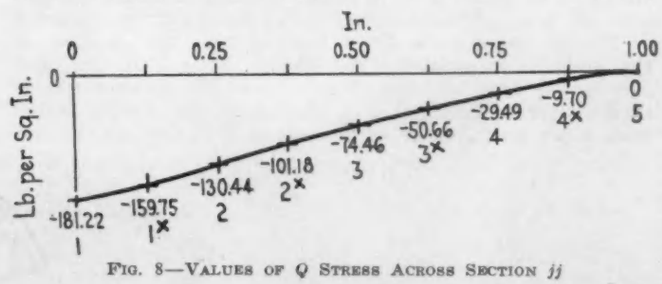

Fig. 8—Values of Q Stress Across Section jj

(*P-Q*) can be taken as the *P* stress only below section *ss*.

Fig. 5 shows the separate values for *P* and *Q* which have been calculated, by the method previously referred to, for the interior boundary. It will be noted that the maximum stress of 862.44 lb. per sq. in. at the interior boundary, which is also the maximum stress found in the model, does not occur at sections *ff* and *nn* (Fig. 3), which pass through the eye normally to the shank, but about 0.115 in. below, at sections *ss* and *tt*. This is contrary to the usual ideas of designers but the point has been checked carefully.

The values of the *P* stress across sections *ss* and *tt* are plotted in Fig. 6. Figs. 7 and 8 show the *P* and *Q* stress respectively across section *jj*.

Conclusions

(1) In an eye-bolt of the type tested, bearing on a pin that fills the eye, a maximum stress equal to 2.87 times the mean stress applied to the shank must be expected at the interior boundary of the hole. This holds for any material obeying Hooke's law of linear proportionality between stress and strain, as can be verified by consultation of the references given

(2) It is natural to conclude that the type of pin or support used will affect the stress distribution appreciably, and in a continuation of this investigation it would seem advisable gradually to reduce the pin diameter, observing the effect upon the maximum stress

THE OIL ENGINE NEEDS RESEARCH WORK

IT must be confessed that the designer of the steam engine and turbine has a far better knowledge of the action going on within the machine than has the designer of the internal-combustion engine. Possible blade speeds, steam velocity and like problems have been solved in a more or less satisfactory fashion. On the other hand, the oil-engine designer is, to a greater or a lesser extent, groping in the dark.

Actual development has reached the point where experimental operation of injection apparatus is obtainable for a two-stroke-cycle oil engine running at 2000 r.p.m. and for a four-stroke-cycle engine running at 4000 r.p.m. But what is going on inside the cylinders? Mechanical ingenuity is far ahead of the physicist. The engineer knows what he can do mechanically, but he knows but meagerly the possibilities and limitations of the liquid fuels he is using in the engine. For example, in the high-speed injection engine he is, perhaps, expecting too much regarding the rate of fuel vaporization. What scientific evidence has he that he is not attempting to operate engines faster than the fuel can vaporize?

What if the steam turbine were supplied with water sprayed onto heated entrance faces of the nozzles. How long would it be before a steam engineer would want to know if all this water had time to vaporize before being called upon to react on the turbine blades? We know we cannot, for a given initial pressure and temperature, hasten the conversion of the steam's heat into jet velocity within the nozzle. What is the limit to the rate at which the individual molecules of the water can be accelerated among themselves in vaporizing? The steam engineer does not need to know because he can have vaporization occur in the boiler without having to have it keep in exact step with the revolutions of the engine.

Not so with the solid-injection oil-engine. Has the fuel in a high-speed solid-injection engine time to vaporize before called upon to burn and create pressure on the pistons? Granting that the liquid fuel under these conditions first cracks, can the carbon then freed burn in time to give good efficiency at 2000 cycles, and much less, per min.? To what extent is the heat economy in an engine better when the fuel is first vaporized instead of immediately cracking into hydrogen and free carbon? This knowledge would be for general use and benefit. Is it not time that our college laboratories were set upon such findings and vigorously supported? They have among them a variety of talent that a Government bureau cannot attract and command; hence, in that respect they are the more favorably endowed for initiating original research. German schools do it. Can ours?—*Power.*

WORLD'S STOCK OF MONETARY GOLD

NEVER before in the world's history was such a concentration of all procurable gold in the monetary stocks of the metal effectuated as during the European War. For this purpose the currency in actual circulation almost all over the globe was wrung dry of gold coin, only an insignificant part of the new gold produced by the world's mines was allowed to be diverted to other than monetary uses and whole populations were induced on grounds of patriotic duty to let their gold jewelry and ornaments go to the melting pot.

While, however, this large general increase of the world's stocks of monetary gold is of the greatest economic importance, the state of the monetary gold holdings of the countries of Europe has a more direct bearing upon the question of the probable international movements of gold in the near future. The total holdings of gold by all European countries except Greece, Portugal and the small new Baltic States were 8 per cent greater at the end of 1924 than at the end of 1913; in other words, the large increase in the gold stock of the United States has not been at the expense of the gold stock of Europe, as so many Americans assume. Even this comparison is misleading, however, since the true condition of things is obscured by the inclusion of Russia, now no longer a real member of the economic society of nations. With the figures for Russia omitted it is found that Europe's holdings of monetary gold increased almost 44 per cent from 1913 to 1924. No actual deficiency of monetary gold in Europe as a whole exists, though the distribution of the existing stocks among the various European nations is decidedly uneven and considerable movements of gold between these nations may reasonably be expected as the economic fabric of Europe is restored. In any case, however, the figures afford little evidence of such European need of American gold as would naturally cause our gold holdings to be drawn upon seriously.—A. R. Marsh in *Economic World.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between June 10 and July 10, 1925. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ADAMS, LYMAN D. (A) general manager, Barnes Gibson Raymond, Inc., 6400 Miller Avenue, *Detroit.*

BAILEY, GEORGE M. (A) branch manager, Mack-International Motor Truck Corporation, *Indianapolis,* (mail) 729 North Capitol Avenue.

BREHM, PAUL H. (A) service manager, Fageol Motors Co. of Ohio, *Kent, Ohio,* (mail) 544 Fairchild Avenue.

COLTON, WILLIAM C., JR. (J) tool designer, Mack Avenue Plant, Briggs Mfg. Co., *Detroit,* (mail) 2240 Marquette Avenue.

DEPEW, RICHARD H., JR. (M) aviator and vice-president, Fairchild Flying Corporation, New York City, (mail) 5 Cranford Street, *Forest Hills, N. Y.*

DOLNITSKY, NATHAN (A) instructor in automobile mechanics, Lane Technical High School, *Chicago,* (mail) 1722 North Kilbourn Avenue.

DOWNEY, WILLIAM D. (J) draftsman, Philadelphia Motor Coach Co., *Philadelphia,* (mail) 2633 North Colorado Street.

EAGLE, HENRY (A) president, Chadick, Delamater Corporation, 623 West 23rd Street, *New York City.*

EATON, B. H. (J) motor-vehicle inspector, Bell Telephone Co. of Pennsylvania, *Scranton, Pa.,* (mail) 1007 Fisk Street.

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EWING, STANLEY W. (A) engineer, National Malleable & Steel Castings Co., 10600 Quincy Avenue, *Cleveland.*

FENNER, ARTHUR F. (A) vice-president and division manager, Mack-International Motor Truck Corporation, New York City, (mail) 1732 Jefferson Avenue, *Buffalo.*

FULLER, HENRY J. (A) president and chairman board, Rolls-Royce of America, Inc., Springfield, Mass., (mail) 40 Wall Street, *New York City.*

GIBBS, FRANK R. (A) assistant general service manager, Studebaker Corporation of America, *South Bend, Ind.,* (mail) 2526 Erskine Boulevard.

GOUDARD, MAURICE (F M) ingenieur arts et manufacture, Société Anonyme Solex, 190 Avenue de Neuilly, *Neuilly-sur-Seine, France.*

HERRICK, THOMAS F. (A) rodman, Department of Highways for the Borough of Queens, City of New York, Long Island City, N. Y., (mail) 242 Amity Street, *Flushing, N. Y.*

HIGHAM, WILLIAM HARRY (M) experimental and designing engineer, Bijur Lubricating Corporation, *New York City,* (mail) 1064 Madison Avenue.

HIRSCHLER, HORACE L. (M) president, Horace Remote Control Co., 12 Steuart Street, *San Francisco.*

HOENINGHAUSEN, LEVERETTE (A) draftsman and tool designer, International Motor Co., New York City, (mail) 81 Murray Lane, *Flushing, N. Y.*

HOWARD, MAJOR CLINTON W. (S M) chief engineer, engineering division, Air Service, McCook Field, *Dayton, Ohio.*

HUNTER, FENLEY (A) general manager, Hunter Illuminated Car Sign Co., *Flushing, N. Y.,* (mail) P. O. Box 97.

JOHNSON, C. E. (A) president, Piston Ring Co., *Muskegon, Mich.,* (mail) Sanford and Keatings Streets.

KILBRIDE, JOHN J. (A) Mack-International Motor Truck Corporation, *Chicago,* (mail) 5434 Ellis Avenue.

KOEHLER, H. G. (J) research chemist, Mellon Institute, *Pittsburgh, Pa.*

KRALL, J. I. (A) treasurer, Cleveland Automobile Co., London Road and Euclid Avenue, *Cleveland.*

LANE, EDWIN GEORGE (M) designer, Yellow Coach Mfg. Co., *Chicago,* (mail) 2143 Humbolt Boulevard.

LARSON, CARL OSCAR (M) World Matex Corporation, Ltd., *Berthierville, Que., Canada.*

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LINKERT, HOWARD W. (M) engineer, Wheeler-Schebler Carburetor Co., *Indianapolis,* (mail) 3528 Guilford Avenue.

MCMAHAN, E. V. (M) production manager, Ajax Rubber Co., New York City, (mail) Ajax Rubber Co., *Trenton, N. J.*

MICHELL, WILLIAM PEARSE (M) engineer, International Motor Co., *Allentown, Pa.,* (mail) 24 North West Street.

MOELLER, H. O. (M) division manager, Mack-International Motor Truck Corporation, *Chicago,* (mail) 132 East 23rd Street.

MOON, JOHN ALEXANDER (M) tool designer, Rolls-Royce of America, Inc., East Springfield, Mass., (mail) 214 Oak Grove Avenue, *Springfield, Mass.*

MOORE, G. ARLINGTON (A) inventor and engineer, Moore Invention Corporation, Worcester, Mass., (mail) 148 East 49th Street, *New York City.*

NEUKUMETER, LOUIS H. (J) designer, Brooks Steam Motors, Ltd., *Stratford, Ont., Canada,* (mail) 137 Albert Street.

NORRIS, WILLIAM J. (J) student course, International Motor Co., Allentown, Pa., (mail) 50 Prospect Place, *Brooklyn, N. Y.*

NOYER, LOUIS (A) civil engineer, Schlumberger & Co., 1 Rue Taitbout, *Paris, France.*

PARSONS, JAMES ARTHUR (A) service manager, Ford Motor Co., *London, Ont., Canada.*

PHILLIPS, GEORGE C. (M) senior inspector, Air Service, McCook Field, *Dayton, Ohio,* (mail) 121 High Street.

POLLARD, ROBERT W. (A) sales engineer and purchasing agent, Columbia Axle Co., 850 East 72nd Street, *Cleveland.*

RAUEN, JOHN B. (A) general manager, secretary and treasurer, United States Spring Co., Inc., Los Angeles; secretary and treasurer, United States Bumper Co., Inc., *Los Angeles,* (mail) 1120-26 South Los Angeles Street.

REYNOLDS, JAMES J. (A) representative, Ferodo & Asbestos, Inc., New Brunswick, N. J., (mail) 80 Prospect Street, *Portchester, N. Y.*

RITTER, HARRY E. (A) president, Mid-West Glass Co., 2235 Buck Street, *Cincinnati.*

SCIRA, JOSEPH A. (A) shop foreman, Jerome J. Sloyan, New York City, (mail) 1452 36th Street, *Brooklyn, N. Y.*

SHAW, SIDNEY B. (M) automotive engineer, Pacific Gas & Electric Co., 245 Market Street, *San Francisco.*

SKELLY, JAMES H. (A) tool designer, Lycoming Mfg. Co., *Williamsport, Pa.,* (mail) 829 Nichols Place.

SPENCER, LOUIS MARTIN (A) patent attorney, General Motors Corporation, *Detroit,* (mail) 3044 West Grand Boulevard.

SPILLER, WILLIAM RAYMOND (J) laboratory engineer, White Motor Co., *Cleveland,* (mail) 9523 Carnegie Avenue.

STOCK, E. W. (M) regional service manager, White Motor Co., Cleveland, (mail) 4151 Forest Park Boulevard, *St. Louis.*

SUMNER, LOUIS W. (A) manager, Automotive Engineering Corporation, 2-114 General Motors Building, *Detroit.*

THOMER, FRED (A) designer, International Motor Co., *New York City,* (mail) 405 West 118th Street.

TOWLE, URBAN A. (A) proprietor, Towle's Garage, *Portland, Me.,* (mail) 621 Forest Avenue.

VALENTIN, ERNST, DR. (F M) consulting engineer, Westfalische Strasse 92, *Berlin-Wilmersdorf, Germany.*

WAITE, DONALD B. (J) assistant patent engineer, Studebaker Corporation of America, *Detroit,* (mail) 889 Hazelwood Avenue.

WALWORTH, RICHARD H. (J) mechanical engineer, Steel Products Co., Detroit, (mail) 41 Broad Street, *Hillsdale, Mich.*

WAUTERS, A. (A) foreman of research department, Rickenbacker Motor Co., *Detroit,* (mail) 3046 Hazelwood Street.

WENNSTROEM, ROBERT T. (A) secretary, treasurer and general manager, Van Wheel Corporation, *Oneida, N. Y.,* (mail) 216 Drake Avenue.

WHITE, THOMAS M. (M) production manager, A. B. C. Trailer Truck Co., Inc., *Memphis, Tenn.,* (mail) P. O. Box 3027.

WHITTEN, ERNEST (A) partner, C. E. Whitten & Sons, 40 Central Avenue, *Lynn, Mass.*

Applicants *for* Membership

The applications for membership received between June 15 and July 15, 1925, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ARCHER, LIEUT. CECIL E., engineering division, Air Service, McCook Field, *Dayton, Ohio.*

AUNGER, H. MURRAY, managing director, Murray Aunger Motor Co., Ltd., *Adelaide, South Australia.*

AXFORD, LEE G., draftsman, General Motors Truck Co., *Pontiac, Mich.*

BAEZ, FIRST-LIEUT. RAPHAEL, JR., engineering division, Air Service, McCook Field, *Dayton, Ohio.*

BEECHER, EUGENE L., experimental engineer, Westinghouse Air Spring Co., *New Haven, Conn.*

BENCKE, CHARLES K., president and general manager, Charles K. Bencke & Co., *Bridgeport, Conn.*

BIRNN, CHARLES E., master mechanic, Moto-Meter Co., Inc., *Long Island City, N. Y.*

BOULT, THOMAS CHRISTOPHER, engineer, Morris Motors, Ltd., *Cowley, near Oxford, England.*

BRANDT, ELLIS R., mechanical engineer, Fairbanks, Morse & Co., *Beloit, Wis.*

BROCK, ARTHUR, JR., owner and general manager, Arthur Brook, Jr., Tool & Mfg. Works, *Philadelphia.*

BURRELL, GEORGE A., consulting chemical engineer, *Pittsburgh.*

CARLSON, CARL EDWARD, draftsman, Walden-Worcester-Wrench, Inc., *Worcester, Mass.*

CARTHAUS, WILLIAM J., secretary and treasurer, Correct Motor Fuels, Inc., *Alton, Ill.*

CATHCART, CHARLES D., chief draftsman and assistant engineer, National Automatic Pan Corporation, *Los Angeles.*

CHARLES, H. N., engineer, Morris Motors, Ltd., *Cowley, near Oxford, England.*

COOPER, J. A., foreman of axle and steering department, Morris Motors, Ltd., *Cowley, near Oxford, England.*

COWAN, H. W., sales manager, Charles A. Strelinger Co., *Detroit.*

DINGLE, HOWARD, vice-president and general manager, Cleveland Worm & Gear Co., *Cleveland.*

EDISON STORAGE BATTERY CO., *Orange, N. J.*

FERGUSON, J. L., service manager, William E. Bush, Inc., *Los Angeles.*

FLOYD, JOHN M., factory manager, Sheldon Axle & Spring Co., *Wilkes-Barre, Pa.*

FRASER, EDWIN J., service superintendent, General Motors Truck Co., *Chicago.*

GERARD, EDMOND, president, Gene & Gerard, Inc., *New York City.*

HANKS, REGINALD FREDERICK, technical staff, Morris Motors, Ltd., *Cowley, near Oxford, England.*

HENDRIE, G. S., sales manager, Detroit Gear & Machine Co., *Detroit.*

HEYLMUN, S. L., instructor in automobile mechanics, Wilmington High School, *Wilmington, Del.*

HUFFERD, GEORGE H., experimental engineer, Steel Products Co., *Detroit.*

HYDE, DOUGLAS ANDERSON, assistant to chief engineer, Fifth Avenue Coach Co., *New York City.*

LAAS, A. G., engineering representative, Locomobile Co. of America, *Bridgeport, Conn.*

LIGHTON, L. E., manager of automotive manufacturers sales, Electric Storage Battery Co., *Philadelphia.*

MERIAM, WELLES, associate examiner, United States Patent Office, *City of Washington.*

MEYER, CAPT. JACK L., Adjutant General's office, *Lincoln, Neb.*

MIERAS, MERRITT A., draftsman, I. H. Wilsey, *Chicago.*

MORGAN, CLYDE S., metallurgist, Automobile Machine Co., *Cleveland.*

MUNRO, GORDON H., field representative, Dodge Bros. of Canada, Ltd., *Toronto, Ont., Canada.*

MURPHY, H. W., service manager, Mack-International Motor Truck Corporation, *Detroit.*

NOGRADY, A. T., engineer, Nogrady Differential Co., *Wichita, Kan.*

OBRECHT, L. W., superintendent, Detroit Steel Products Co., *Detroit.*

OLIVER, WALLACE F., assistant chief engineer, Hydraulic Brake Co., *Detroit.*

PORSCHE, DR. FERDINAND, director of technical management, Daimler Motoren Gesellschaft, *Stuttgart-Untertwrkheim, Germany.*

PRALL, B. R., buyer, Montgomery Ward & Co., *Chicago.*

PRENTIS, JOSEPH N., engineer, Cadillac Motor Car Co., *Detroit.*

PRESTON, JACK, district manager, Pennzoil Co., *San Francisco.*

QUINTON, MAJOR A. B., JR., Ordnance Department, *Aberdeen Proving Ground, Md.*

RASCH, WILLIAM W., service manager, New York Rickenbacker Co., *New York City.*

REED, HAROLD V., engineer, Borg & Beck Co., *Chicago.*

RYAN, WALTER D'ARCY, director of illuminating engineering laboratory, General Electric Co., *Schenectady, N. Y.*

SAUL, C. E., research engineer, International Harvester Co., *Fort Wayne, Ind.*

SCATKO, JOSEPH J., mechanical engineer, *Detroit.*

SCHUTTE, HERMANN, president, Schutte Electric Co., *Pittsburgh.*

SEDDON, WILLIAM R., designer, Seddon Motor Car Co., *Flourtown, Pa.*

SMITH, ALWYN GOYDER, technical staff, Morris Motors, Ltd., *Crowley, near Oxford, England.*

STALKER, EDWARD A., assistant professor of aeronautical engineering, University of Michigan, *Ann Arbor, Mich.*

STEWART, H. H., proprietor, New Zealand Stanley Steam Car Co., *Hamilton, New Zealand.*

STOUGHTON, EDWARD L., vice-president and general sales manager, Wico Electric Co., *Springfield, Mass.*

THORNTON, W. H., head tester, Morris Motors, Ltd., *Cowley, near Oxford, England.*

TUCKER, RUFUS S., sales agent, Bethlehem Steel Co., *Bethlehem, Pa.*

VALPEY, HENRY H., quality supervisor, sales engineer clutch division, Long Mfg. Co., *Detroit.*

VAUGHAN, HUGH CHRISTOPHER, manager of service department, Morris Motors, Ltd., *Cowley, near Oxford, England.*

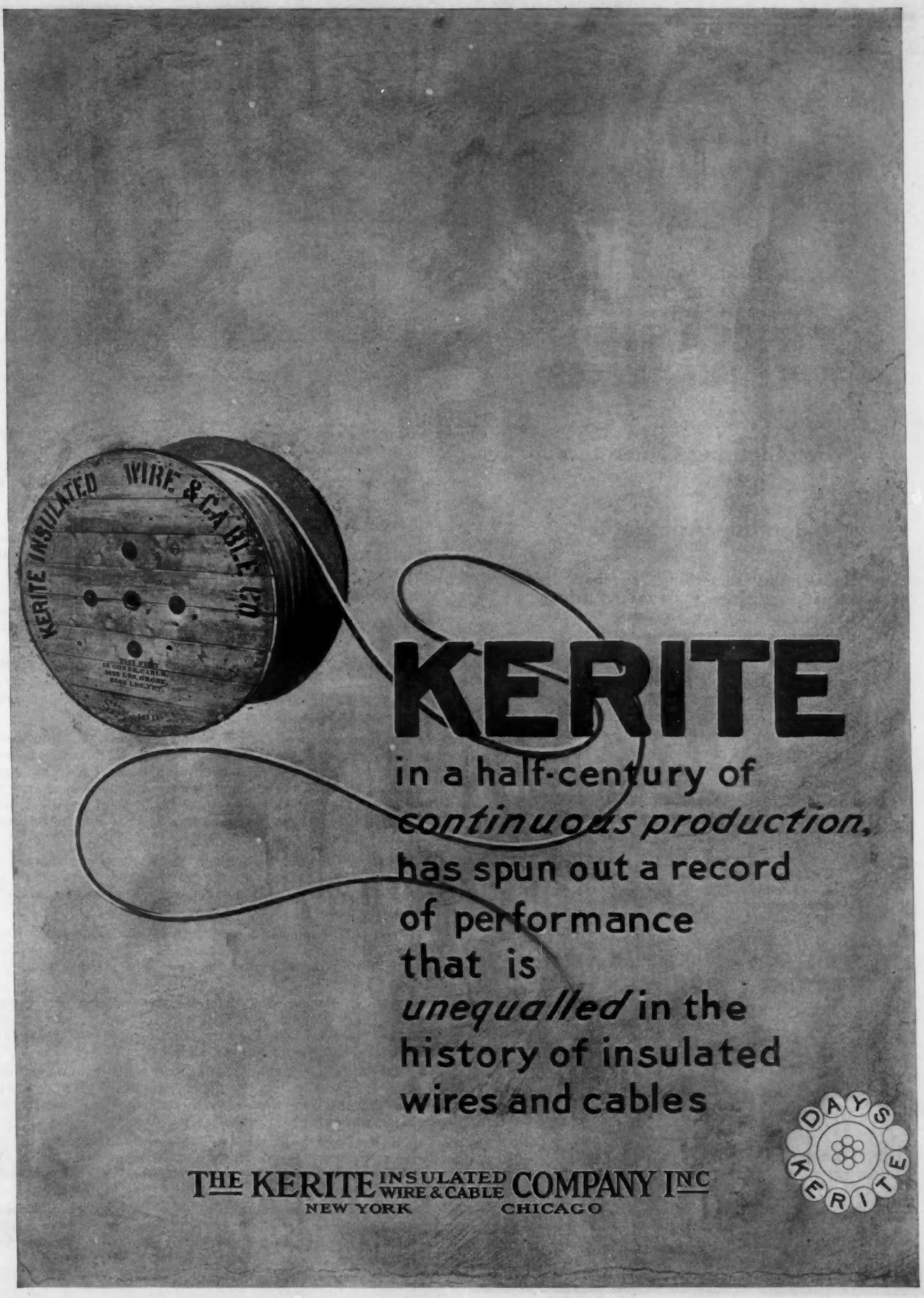
VOLLES, ARTHUR J., assistant engineer, Precision Castings Co., Inc., *Fayetteville, N. Y.*

WALCOTT, ALLAN P., industrial mechanical engineer, *Waterbury, Conn.*

WESTBY, STANLEY, draftsman, Morris Motors, Ltd., *Cowley, near Oxford, England.*

WEIGAND, G. F., sales engineer, Spicer Mfg. Corporation, *South Plainfield, N. J.*

WILLIAMS, HARRY S., assistant superintendent of equipment, Department of Street Railways, *Detroit.*


KERITE INSULATED WIRE & CABLE CO.
KERITE
in a half-century of
continuous production,
has spun out a record
of performance
that is
unequalled in the
history of insulated
wires and cables
DAYS
KERITE
THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO

OPEN TYPE

"NORMA"
PRECISION
BALL BEARINGS

For Lighting Generators

and

Ignition Apparatus

Substituting something "cheaper" for something known to be better, usually has effects that are anything but economical.

Makers of high-grade ignition apparatus and lighting generators still insist upon using "NORMA" Precision Ball Bearings in their high-grade units. They cannot afford the risks of substitution, because—

Service records prove that magnetos and lighting generators with "NORMA" Precision Ball Bearings, run more quietly, last longer.

A booklet will be sent on request. And our engineers will welcome an opportunity to work with yours.

NORMA-HOFFMANN
BEARINGS CORPORATION
Stamford — Connecticut
PRECISION BALL, ROLLER AND THRUST BEARINGS

CLOSED TYPE

Personal Notes of the Members

Items regarding changes in business connections, promotions, etc., are desired from the membership for insertion in these columns. This will enable members to keep their friends informed of their whereabouts and will also assist in keeping the records of the Society up to date.

C. H. Alvord has become associated with the Ware Radio Corporation, New York City, as works manager. He was formerly factory manager for Gray & Davis, Inc., Cambridge, Mass.

David Ayr has been appointed assistant factory manager of the Pratt & Whitney Co., Hartford, Conn. Prior to establishing this connection he was assistant general manager of the equipment division of the American Radiator Co., Buffalo.

Kelvin C. Backhouse, who was until recently draftsman and assistant experimental engineer for Demattia Bros., Garfield, N. J., has been made assistant engineer for the Ruckstell Axle Co., New York City.

Ralph Baggaley, Jr., has accepted a position with the Elco Works, Bayonne, N. J. He was formerly Durant inspector in Hayes & Hunt, Durant Motors, Inc., of New Jersey, Elizabeth.

P. L. Barter, vice-president in charge of sales of the McCord Radiator & Mfg. Co., Detroit, will assume the duties of the sales manager of the replacement parts department, which office has just become vacant.

The Ward Vehicle Co., Mount Vernon, N. Y., announces the following changes in its personnel: **H. N. Baxter,** who was mechanical engineer, has been appointed assistant chief engineer; **O. E. H. Froelich,** formerly engineer in charge of development and design, has been made chief engineer, and **R. L. Smith,** who was assistant engineer, is now purchasing agent.

Hubert D. Bennett is no longer assistant sales manager of the New York branch of the Studebaker Corporation of America, but has been made general manager of the C. H. Durfee Products Co., also of New York City.

Alfred D. Benson has joined the testing department of the General Electric Co., Schenectady, N. Y. Prior to making this connection he attended the Ohio State University, Columbus.

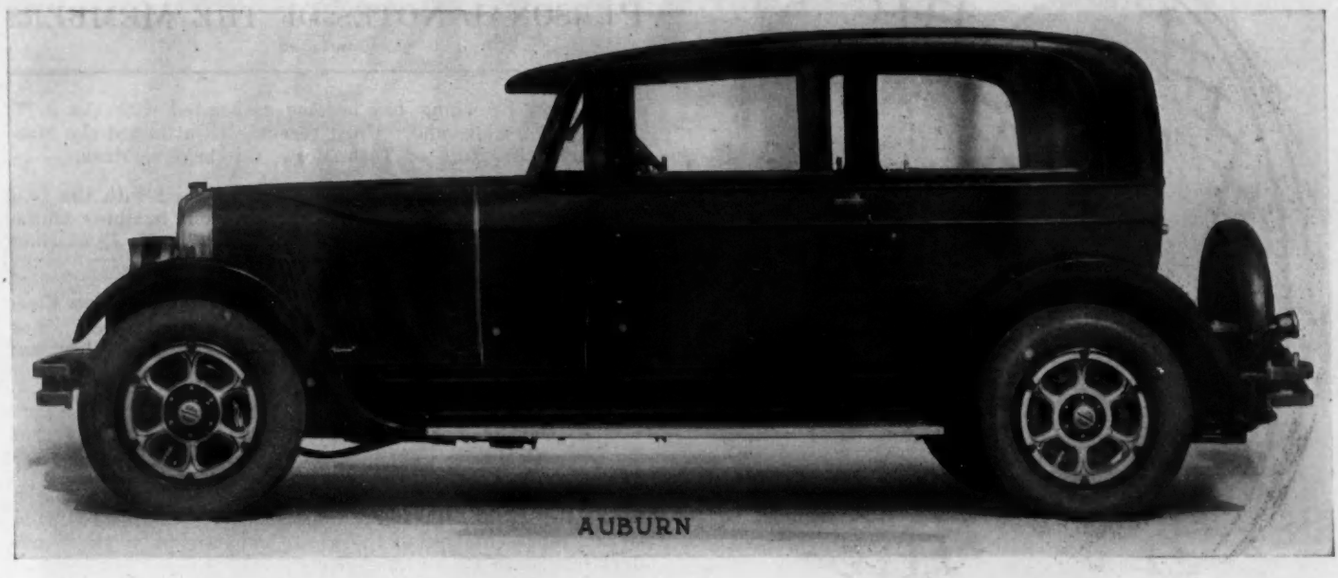
Charles H. Boone, who until recently was chief draftsman for the Clark Equipment Co., Buchanan, Mich., has become sales engineer for the Vacuum Oil Co., and will make his headquarters at Grand Rapids, Mich.

L. D. Boyce has accepted a position with the Carter Carburetor Corporation, St. Louis, as engineer. His previous business connection was with the Ensign Carburetor Co., Chicago, where he held a similar position.

Paul M. Boyd has joined the engineering department of the Curtiss Aeroplane & Motor Co., Inc., Garden City, N. Y. He formerly attended the Massachusetts Institute of Technology, Cambridge, Mass.

Announcement has been made of the resignation of **Robert W. A. Brewer** as president and chief engineer of the Engineers Development Co., Philadelphia. He will continue his consulting practice at **Ridley Park, Pa.**

(*Continued on p.* 4)



SMITH EXPANDED WHEELS

accentuate the fine lines of a car. They are the wonder Wheel for appearance and they are just as good as they look. Their ever exact roundness and trueness at all points lends to quicker acceleration of the car, the maintenance of speed, with less gas, and the lengthening of the life of the tires. Furthermore, with this exact roundness and trueness, the wheels run absolutely straight, thereby lessening the amount of steering that has to be done.

Their great strength will never permit them to collapse, letting the car down, injuring its occupants, no matter what the impact or side strain may be.

SMITH WHEEL INC.
SYRACUSE, N.Y.
Established 1845

THE essential principle of the balloon tire being to *absorb* the shocks and blows of travel, rather than *resist* them, the balloon tire requires a different type of material from that formerly used in tire construction. Recognizing that fact, Goodyear conceived and perfected SUPERTWIST, the extra-elastic, extra-durable cord fabric that far outstretches the breaking point of the cord fabric ordinarily employed. SUPERTWIST yields to impact, stretches and recovers. A longer-wearing, greater-mileage tire is the result. You want the benefits of SUPERTWIST—you get them only in Goodyear Tires.

Good tires deserve good tubes—
Goodyear Tubes

GOODYEAR

Copyright 1925, by The Goodyear Tire & Rubber Co., Inc.

PERSONAL NOTES OF THE MEMBERS

Continued

Harrison Browning has become associated with the J. T. Tractor Co., Cleveland. Until recently he attended the Massachusetts Institute of Technology, Cambridge, Mass.

Joseph H. Burroughs, Jr., is now associated with the Otis Elevator Co., New York City. His previous business affiliation was with the Kelsey Motor Co., Belleville, N. J., as chief engineer.

F. L. Creager has become associated with the Wico Electric Co., West Springfield, Mass., as research engineer. Prior to establishing this connection he was in charge of electrical laboratory, ignition equipment, motor and generator tests for Fairbanks, Morse & Co., Beloit, Wis.

V. A. Davison has been appointed production manager of the General Motors Continental S/A, Antwerp, Belgium.

William R. Deeble, who was formerly associated with the Fuller Brush Co., Hartford, Conn., has been appointed field service representative of the group department of the Travelers Insurance Co. of that city.

James J. Dimeo has accepted a position as manager of the Permold Co., Cleveland.

Beldon G. Elliott is doing apprentice work for the International Motor Co., Allentown, Pa. Until recently he attended the Clarkson School of Technology, Potsdam, N. Y.

Heman Ely has retired from the Timken Roller Bearing Co., Canton, Ohio. He has been associated with the Timken Company in various capacities for 16 years, and has been vice-president and treasurer since 1920. No announcement has been made of his future plans.

Walter H. Ewend has been appointed minor mechanical inspector of finished cars for the Packard Motor Car Co., Detroit. He formerly attended the University of Illinois, Urbana.

F. P. Freeman, who was previously superintendent of motor equipment for the Kaufman's Department Stores, Inc., Pittsburgh, has become affiliated with the Public Service Transportation Co., Newark, N. J.

M. W. Gaffney is no longer body engineer for the Fisher-Gaffney Body Co., San Francisco, but has accepted a similar position with the California Motor Coach Co., also of San Francisco.

J. R. Hemeon, until recently research engineer and chief inspector for Snead & Co. Iron Works, Jersey City, N. J., is now located at South Plainfield, N. J., the Snead cushion drive division having been taken over by the Spicer Mfg. Co., South Plainfield.

William E. John, who was formerly vice-president of the Hall Wheel Corporation, Philadelphia, is now associated with the Buffalo Gasolene Motor Co., Buffalo.

Raymond D. Kelly has been appointed junior aeronautical engineer in the instrument branch of the engineering division of the Air Service, McCook Field, Dayton, Ohio. He previously attended Purdue University, West Lafayette, Ind.

Emil F. W. Krause has resigned as sales engineer for the National Utility Battery Co., Mount Prospect, Ill. His future plans have not been announced.

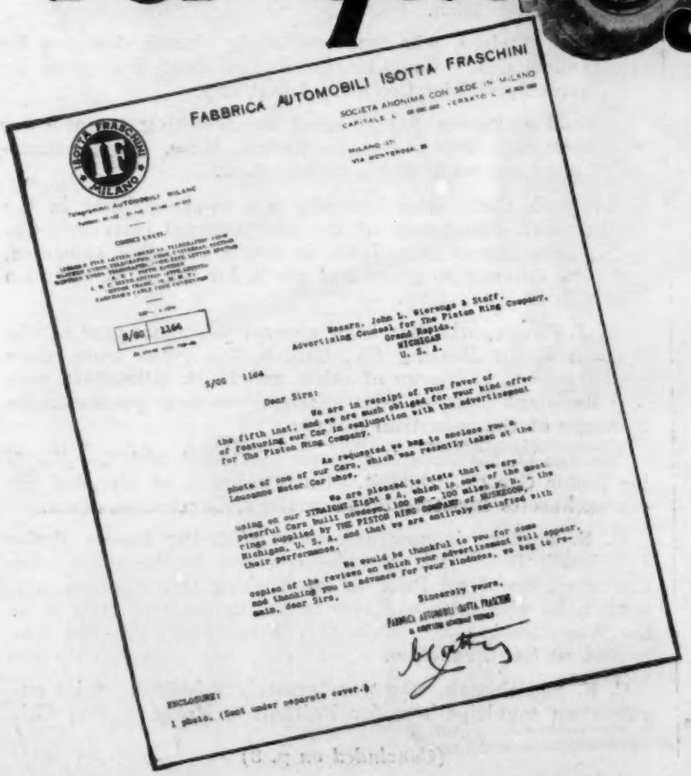
Robert P. Lay has accepted a position as chief engineer for the Penn Spring Works, Inc., Baldwinsville, N. Y.

Robert B. Landis, who was previously engaged as electric test man for the Autocar Co., Ardmore, Pa., has become associated with the Autocar Sales & Service Co., St. Louis, as salesman in the electric-truck division.

(*Continued on p.* 6)

QUALITY
Piston Rings

for quality engines



FABBRICA AUTOMOBILI ISOTTA FRASCHINI

SOCIETA ANONIMA CON SEDE IN MILANO

Via Monterosa

Telegrammi: AUTOISOTTA MILANO

S/OS 1164

Messrs. John L. Sterenge & Staff.
Advertising Counsel for The Piston Ring Company.
Grand Rapids.
MICHIGAN
U. S. A.

S/OS 1164

Dear Sirs:

We are in receipt of your favor of the fifth inst. and we are much obliged for your kind offer of featuring our Car in conjunction with the advertisement for The Piston Ring Company.

As requested we beg to enclose you a photo of one of our Cars, which was recently taken at the Lourenco Motor Car shop.

We are pleased to state that we are using on our STRAIGHT Eight 8 A, which is one of the most powerful Cars built nowadays, 100 HP - 100 miles p. h. - the rings supplied by THE PISTON RING COMPANY of MUSKEGON, Michigan, U. S. A. and that we are entirely satisfied with their performance.

We would be thankful to you for some copies of the reviews on which your advertisement will appear, and thanking you in advance for your kindness, we beg to remain, dear Sirs,

Sincerely yours,
FABBRICA AUTOMOBILI ISOTTA FRASCHINI

ENCLOSURE:
1 photo. (Sent under separate cover.)

Showing Isotta Fraschini *Straight Eight 8A* — 100 H. P. — 100 miles p.h., equipped with Quality Piston Rings.

QUALITY

NO-LEAK-O

DRAINOIL

SEALDRAIN

The Piston Ring Company

Muskegon, Michigan

Exide
BATTERIES

Incorporated in the Exide automobile battery, along with the plates, separators and electrolyte, is the 37 years experience of its makers—the world's largest manufacturers of storage batteries for every purpose.

That's what makes it the long-lasting, dependable and economical choice of millions of motorists.

That too, is what makes it the choice of automotive engineers—the men who demand in addition, maximum cranking ability with minimum size and weight.

THE ELECTRIC STORAGE BATTERY CO.
Philadelphia

In Canada, Exide Batteries of Canada, Ltd.
153 Dufferin St., Toronto

PERSONAL NOTES OF THE MEMBERS

Continued

Mario Luigi Luiggi, who was until recently development engineer of the Hyatt Roller Bearings Division of the General Motors Corporation, Harrison, N. J., has been transferred to the General Motors Export Corporation, Detoit.

James S. McDonnell, Jr., has been made aeronautical engineer for the Stout Metal Airplane Co., Dearborn, Mich. Prior to making this connection he held a similar position with the Consolidated Aircraft Corporation, Buffalo.

Bertram C. Manby, research and consulting automotive engineer, who was formerly in Guildford, New South Wales, Australia, is now located at Carnegie, Pa.

Frederick J. Manning, who was graduated recently from the Worcester Polytechnic Institute, Worcester, Mass., with the degree of mechanical engineer, has been appointed inspector of motor-vehicle traffic for the department of registry of motor vehicles, Commonwealth of Massachusetts, Worcester.

William S. Marsden has become affiliated with the Cadillac Motor Car Co., Detroit, as engineering apprentice for 1 year. He formerly was assistant instructor in engineering mechanics at the Sheffield Scientific School, Yale University, New Haven, Conn.

E. T. Mathewson has opened an office in Buffalo and will conduct a sales engineering business.

J. F. Merkel is no longer designing and experimental engineer for G. R. S. Products, Inc., Albany, N. Y., but has become designing engineer for the General Railway Signal Co., Rochester, N. Y.

Albert F. Mohr, who was formerly engineer for the Hyatt Roller Bearings Division of the General Motors Corporation, Harrison, N. J., has been made sales engineer for the Timken Roller Bearing Co., Canton, Ohio.

LaRue H. Nagler has accepted a position with the General Motors Research Corporation, Detroit. Until recently he was a student at the Michigan State College of Agriculture, East Lansing, Mich.

Moritz Nielsen, who was previously chassis designer for the Yellow Coach Co., Chicago, is now chief draftsman for the Metal Specialties Co., also of that city.

Harold F. Peavey has resigned as consulting engineer for the Springfield Bronze Co., Springfield, Mass. No announcement has been made of his future plans.

Louis F. Pietz, who formerly was road engineer in the motor truck department of the International Harvester Co. of America, Sioux City, Iowa, is now a traveling salesman, handling automotive gears and parts, for the R. C. Schwinn Co., also of Sioux City.

H. J. Porter, who has been general sales manager of the Timken Roller Bearing Co., Canton, Ohio, has been made vice-president in charge of sales, and **L. M. Klinedinst,** who was assistant general sales manager, is now general sales manager of the industrial division.

Thomas O. Richards has become affiliated with the Cadillac Motor Car Co., Detroit. Until recently he attended the Massachusetts Institute of Technology, Cambridge, Mass.

R. S. Sanford is now associated with the Bendix Brake Co., South Bend, Ind., as sales engineer in the motorcoach and truck division. Prior to establishing this business connection he was sales engineer in the automotive division of the Westinghouse Air Brake Co., Wilmerding, Pa., and was located at San Francisco.

C. K. Sencebaugh, who was formerly industrial sales engineer on municipalities for Fairbanks, Morse & Co., Chi-

(*Concluded on p.* 8)

Hyatt *Simplicity* Benefits....

The Manufacturer

Hyatt Roller Bearings simplify design, speed assembly and lower production costs. They also effect manufacturing economies by lowering the percentage of knock-downs—assuring maintenance of production schedules and uniform quality of product.

The Dealer

Hyatt bearings simplify the dealers' problem for they reduce bearing complaints to a minimum and build owner confidence. Their long life and freedom from adjustment are selling points that appeal.

The Owner

The owner finds his Hyatt bearings never need adjustment. Because they leave him free of bearing trouble and outlast his car, he almost forgets their existence in his satisfaction with the car he drives. Obviously a "Hyatt-ized" car is his preference.

HYATT *Quiet* Roller Bearings

THE SIGN OF OFFICIAL HYATT SERVICE

AUTHORIZED UNITED MOTORS SERVICE HYATT ROLLER BEARINGS

HYATT Roller Bearings absorb road shock and driving strain—maintain proper alignment of shafts and gears—yet never require adjustment. Being quiet, rugged and long-lived, they seldom need attention. Because of these advantages they add prestige to the transportation they equip.

HYATT ROLLER BEARING COMPANY

NEW YORK DETROIT CHICAGO SAN FRANCISCO

Worcester Philadelphia Charlotte Pittsburgh Cleveland

WHETHER in wheels, along the line by which power is carried from engine to road, or in steering column or steering knuckle, Bock Taper Roller Bearings carry side or end loads, eliminate friction, and almost always outlive the car.

There are convincing reasons for Bock superiority, based on design, material and workmanship. We shall be glad to give these in detail to any interested executive, and to furnish samples for testing.

THE BOCK BEARING COMPANY, Toledo, O.

BOCK

***Quality* TAPER ROLLER BEARINGS**

PERSONAL NOTES OF THE MEMBERS

Concluded

cago, has been appointed manager of the Chicago branch of the Superior Gas Engine Co., Springfield, Ohio.

B. Steensen has joined the experimental engineering department of the Chrysler Corporation, Detroit. Until recently he was a student at the University of Detroit, of that city.

At the recent annual election of officers of the Automotive Service Association of New York, among those elected were **H. Ivan Stengel**, maintenance engineer of the Uppercu Cadillac Corporation, as president; **Charles Hansa**, superintendent of the automotive department of Bonwit-Teller Co., third vice-president, and **William E. Kemp**, William E. Kemp Co., fourth vice-president.

Warner T. Tabb has resigned as engineer in the governor division of the Eisemann Magneto Corporation, Brooklyn, N. Y. Previous to this he was chief engineer for the Duplex Engine Governor Co., Inc., also of Brooklyn. No information regarding his future plans has been given out.

Lieut. Thomas K. Vincent, who was formerly stationed at Raritan Arsenal, Metuchen, N. J., has been transferred to the Watertown Arsenal, Watertown, Mass.

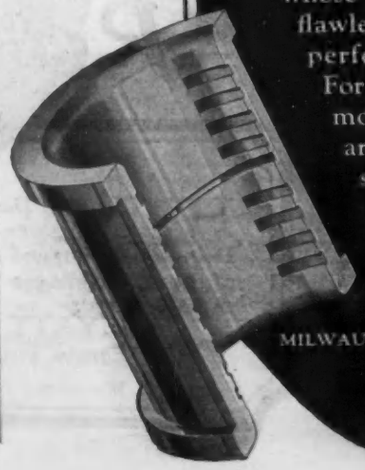
K. D. Vosler has become affiliated with the Hamilton Aero Mfg. Co., Milwaukee, in the capacity of factory manager. Prior to establishing this connection he was on the engineering staff of the Consolidated Aircraft Corporation, Buffalo.

Edgar L. White has accepted a position as assistant in the research laboratory of the James B. Clow & Sons Co., Newcomerstown, Ohio. Until recently he was a student at Ohio State University, Columbus.

H. Willshaw, who was formerly superintendent of the manufacturing office of the Dunlop Tire & Rubber Corporation of America, Buffalo, is now associated with the Dunlop Rubber Co., Ltd., Fort Dunlop, Erdington, Birmingham, England.

MILWAUKEE

DIE CASTINGS AND BEARINGS



As very essential and basically important parts of any motor, bearings are deserving of just as serious consideration and careful selection as other vital units upon whose correct design and flawless quality successful performance depends. For this reason leading motor manufacturers are more and more specifying "*Milwaukee Bearings*".

May we exchange specifications?

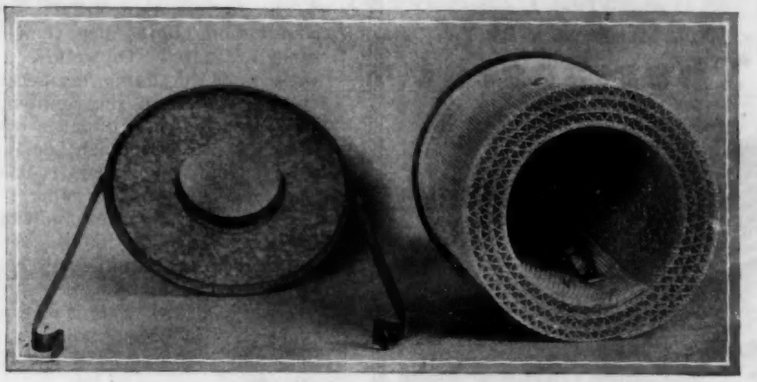
MILWAUKEE DIE CASTING CO.
297 4th Street
Milwaukee
Wisconsin

ENGINEERS

Here's An Air Cleaner That Exactly Fits Your Ideal

AIR-MAZE

Amazingly Simple **Marvelously Efficient**



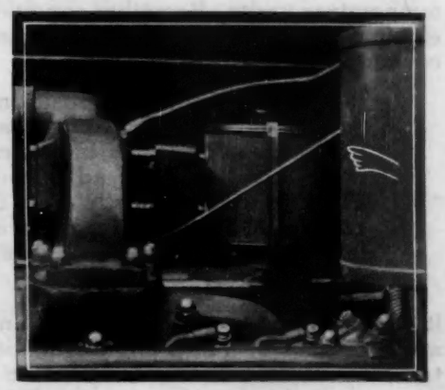
The automotive engineer wants:

(1) An air cleaner that sets up no perceptible vacuum ahead of the carburetor,
(2) That is practically 100% efficient,
(3) That is compact enough to go into available space,
(4) That will require no attention or cause trouble for owner,
(5) That has no moving parts,
(6) That is easy to clean and to get at.
(7) No change in carburetor adjustment necessary.

The Air-Maze exactly fits these requirements.

Developed from a principle invented by an air filter expert. In use many years for cleaning the gases in blast furnaces, on air compressors and in hospitals and photographic plate plants where pure air is necessary.

Briefly, the Air-Maze has but three parts, top, bottom with cork washer and roll of layers of flat and crimped wire screen dipped in non-drying paraffin oil. The small streams of air are uniformly baffled and caused to swirl and deposit all dust and foreign matter on the oiled screen. Will never give trouble and need not be cleaned or oiled but once a year under average conditions.



Many progressive car manufacturers are now equipping. Air-Maze equipment not only saves the car maker much expensive service and annoyance but gives him a very valuable sales and advertising advantage.

Descriptive literature, prices and test equipment quickly available.

Write or call any of the following

AIR-MAZE CORPORATION

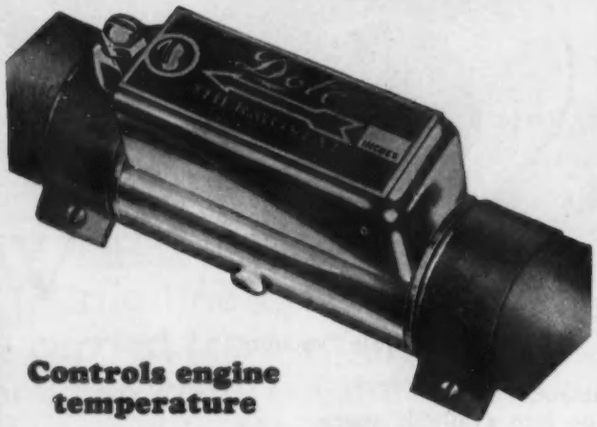
587 Fifth Avenue, New York City

12-251 General Motors Building, Detroit, Mich. **1629 Union Trust Building, Cleveland, O.**

Dole

Automotive Necessities

Dole Red Arrow Thermostat



Controls engine temperature

The Dole Red Arrow Thermostat brings the engine temperature to the most efficient point in the shortest possible time. It maintains this most efficient temperature under all weather conditions, driving loads and varying speeds. In its operation, the Dole Red Arrow Thermostat so absolutely controls and maintains an ideal water temperature under all weather conditions that it eliminates entirely the use of all forms of radiator coverings.

It is a year-round proposition—can be installed by any garage mechanic in from ten to fifteen minutes—never requires adjustment and operates efficiently with the same adjustment in hot or extremely cold weather and at high or low speeds.

It reduces greatly crank case dilution and the water content of lubricating oil in the oil pan, which results in economy of fuel, ease of operation and elimination of various engine troubles.

Complete information sent on request

DOLE VALVE CO.

1923-33 Carroll Ave. • • Chicago

Notes and Reviews

This column, which is prepared by the Research Department, gives brief items regarding technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The High-Speed Internal-Combustion Engine. By Harry R. Ricardo. Published in *The Automobile Engineer*, May, 1925, p. 135; and June, p. 166.

This series of articles is a general introduction to the thermodynamics of the internal-combustion engine. Opening the series is a discussion of the field of this type of prime mover, in which the author predicts a great development of its sphere of usefulness.

The factors that influence the efficiency of the internal-combustion engine are then enumerated, and their importance evaluated. Of weight in this respect are the expansion ratio and the flame temperature, but loss of heat to the cylinder-walls, in the opinion of the author, exerts only a small part of the influence commonly attributed to it. Neither has the load much bearing on efficiency, as over a wide range, when the load is reduced by throttling, the indicated efficiency remains the same.

Detonation and the conditions that cause it are described, as is pre-ignition. To the tendency of the fuel to detonate is ascribed the dominating role of governing the expansion ratio. Other significant conditions are set forth, and the conclusion drawn that the range of most-favorable compression-ratios is between 6.0 to 1 and 7.5 to 1. A few practical applications of the theoretical discussion close the first article.

In the opening paragraphs of the second article, the part turbulence and the latent heat of evaporation play in engine operation is taken up. The author then justifies his emphasis on efficiency by explaining how increasing engine efficiency also increases reliability and durabilty.

The Testing of High-Speed Internal-Combustion Engines. By Arthur W. Judge. Published by D. Van Nostrand Co., New York City. 392 pp.; 242 illustrations.

In writing this book, the author has steered a course between a too elementary and a too advanced treatise. His aim was to meet the needs of internal-combustion engineers, manufacturers, test and laboratory assistants, students and others who have to deal with the testing of engines. For this reason much of the subject matter is of a fairly elementary nature, while for the advanced worker and research engineer, a general survey is given, supplemented with footnote references to original papers and results. Testing methods and instruments used in this and other countries are described in detail, and the book is brought thoroughly uptodate. The book treats particularly of automobile and aircraft engines, but a substantial part of the information given is applicable also to other internal-combustion engines.

The opening chapter summarizes the general theory of the internal-combustion engine, after which various types of test procedure are enumerated. Methods of making fuel tests and exhaust-gas analyses are described as are the measurements of air supply, water supply and heat, brake horsepower, pressure and temperature. How the completed automobile or aircraft engine is tested is the next subject and a final chapter contains an analysis of high-frequency movements.

Mechanics of Machinery. By Robert C. H. Heck. Published by McGraw-Hill Book Co., New York City. 550 pp.; 658 illustrations.

A study of motions and forces within machines is made in this volume. This subject is said to be of importance not only because it has a direct bearing on design, but also because it furthers an understanding of the working of ma-

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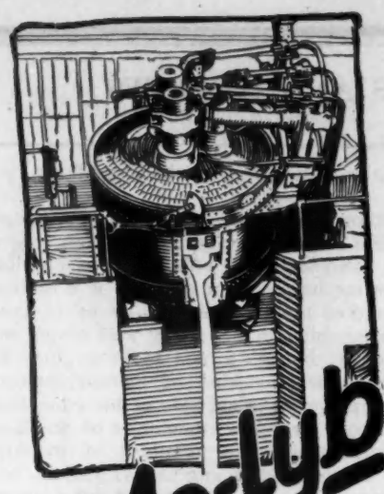


Mo-Lyb-den-um Steel

PUTS WAR TIME ARMOR PLATE TOUGHNESS IN SRB BALL BEARINGS

Molybdenum Steel in SRB Balls Gives Greater Toughness—Greater Hardness —Greater Strength—and Greater Load Carrying Capacity and Durability

Out of the War came Molybdenum Steel for three reasons:

1. *Greatly Increased the Strength and Toughness of Armor Plate.*
2. *Alloy Obtainable in America in Sufficient Quantities for All Steel Purposes Making the Supply Independent of Foreign Sources.*
3. *The only Alloy which Could be Introduced into Steel in an Absolutely Pure State.*

SRB Engineers, searching for new methods to increase the endurance qualities of ball bearings, have conducted laboratory and service tests on Molybdenum steel balls for the past four years. Since the capacity of an Annular Ball Bearing is in general proportional to the number, size and strength of the balls contained therein, it is now possible, through the use of this steel in SRB balls, to give SRB Ball Bearings the following advantages over those containing the regulation Chrome Alloy Steel Balls:

Increased Toughness and Breaking Strength....Greater and More Uniform Hardness....Extraordinary Load Carrying Capacity....Maximum Ball Endurance.

Longer bearing life is thus made possible through the increased hardness along with the unusual toughness obtainable with this molybdenum steel. The dense, fine grain structure and cleanness of this steel give further assurance of consistently high capacity and endurance qualities.

As the demand for greater capacity in ball bearings has in the past been limited to the larger sizes, Standard Steel and Bearings Incorporated now use a chrome molybdenum electric furnace steel for balls of one inch diameter or larger, thus giving SRB Bearings of these sizes load carrying capacities and endurance qualities formerly considered impossible. Other sizes are constantly being added to keep pace with the requirements of our customers. Write us for information.

SRB

Standard Steel and Bearings Incorporated

Plainville *"Use Standard Ball Bearings—First"* Connecticut

2532

Ball Bearings Clinch Sales

*Says Sammy Salesman**

In comparison with the rest of a car, ball bearings don't look so big. But, take it from me, they're the whole show in determining how easy a car runs.

Only the other day a fellow came into the store to see our new fall model. While we were talking, he happened to lean against the back end of the car, and the car moved. Think of it—a car of several thousand pounds, gliding along the floor just from the weight of a man leaning against it.

Naturally the incident impressed my customer. Of course, I then started to talk about the car's bearings, ball bearings, and how these bearings make it the smoothest running car in its class.

I made the sale. But the ball bearings really clinched it.

THE FAFNIR BEARING CO.

Manufacturers high grade ball bearings—the most complete line of types and sizes in America

NEW BRITAIN, CONN.

Newark Chicago Cleveland Detroit

**Any Automobile Salesman.*

FAFNIR

BALL BEARINGS

THE MOST COMPLETE LINE OF TYPES AND SIZES IN AMERICA

NOTES AND REVIEWS

Continued

chines, and the principles which they embody and put into action.

In his work, the author has used as a guide the thought that, in the crowded field of engineering study, each subject should be presented as compactly and effectively as possible. In his opinion, also, the mechanics of machinery is a distinct division that can be handled most forcibly if its parts, commonly scattered, are assembled in one body and given correlated treatment. Finally, he has aimed to bring into his book a certain cultural value, the kind of mental training that the engineer needs on the technical side of his education.

Main divisions of the book are: the kinematics of displacement, velocity and acceleration; the graphics of machine forces; the mechanics of the piston engine; vibration, balance testing and gyrostatic action; friction and lubrication; engine governors; a group of special problems and problems of power transmission.

Farm Motors. By Andrey A. Potter. Published by McGraw-Hill Book Co., New York City. 299 pp.; 279 illustrations.

This volume is the latest of three editions, the first of which appeared in 1913. In the second or 1917 edition, the chapters on gasoline and oil engines and on traction engines were enlarged, those on steam engines rewritten and new chapters added on automobiles and animal motors. In the present volume the author has still further expanded the chapters on gasoline and traction engines and improved other chapters, bringing the work into harmony with the improvements of recent years. The treatise was written primarily for the student of agricultural engineering, but much material of interest to the automotive engineer is also included.

In comparing the costs of the various types of farm motive power, the author states that with the horse the cost of power per horsepower-hour varies from 5 to 6½ cents, a figure which, with stationary gasoline engines, is reduced to from 1½ to 2½ cents. The internal-combustion engine, he says, is the most important form of power for modern farms. A chapter is devoted to the characteristics of the internal-combustion engine as it is adapted to farm work, while the general principles governing the construction of automobiles, their operation and maintenance form the subject matter of another division. The various traction engines now used are also described.

The Berk Supercharger. Published in *The Autocar*, May 29, 1925, p. 936.

The Berk supercharger, an English product, is said to differ from other superchargers in having rotors with three blades instead of two. Two of these rotors run together in a housing, with a clearance between the blades of a few thousandths of an inch. However, the rotors do not drive each other like gears but are driven by separate gears of an ordinary type placed in a compartment in the supercharger housing. To keep the supercharger cool, fins are cast on the housing, and even the air or gasoline passing from the supercharger has to go through an intermediate cooler before entering the engine.

All about Superchargers. By B. M. Ikert. Published in *Motor Age*, May 21, 1925, p. 12.

Supercharging is defined as forcing a greater volume of explosive mixture into the cylinders of an internal-combustion engine than could normally be drawn into them by the suction of the pistons. Superchargers are designed to increase the engine power-output without an increase in the size of the engine. Incidentally, the supercharger also makes possible the use of ordinary inlet and exhaust cams in the high-speed engine, renders unnecessary extremely accurate valve-timing and mechanically breaks up and more completely atomizes fuel. The future missions of the supercharger

(*Continued on p.* 14)

There is only ONE Duco — DU PONT Duco

DUCO is not a process nor a type of material. It is a specific *product* created and manufactured *only* by du Pont. It is not a paint nor a varnish. It is a finish of glass-like smoothness and astonishing durability.

Naturally, a product with such remarkable qualities and immediate acceptance by the public is widely imitated. DUCO is receiving its full measure of this flattery.

But the fundamental behind DUCO *never* can be imitated —for the accumulated experience of du Pont chemical engineers stands alone.

E. I. DU PONT DE NEMOURS & CO., Inc.
Chemical Products Division
Parlin, N. J., Flint, Mich., San Francisco, Cal., Everett, Mass.
Canadian Distributors: Flint Paint and Varnish Limited, Toronto

The "Why" Of Modine's Greater Cooling Capacity

The Modine principle of air control effects the greatest possible rate of heat absorption from the water. This is why Modine Radiators have greater cooling capacity per pound of core material than any other construction. Proved by use in every service.

Extra large water channels—one piece channel construction—extra heavy copper stock—3/16 inch solid metal face are some of the reasons for Modine's strength and durability.

Cushman Motor Works, Lincoln, Nebraska, are among the leaders that insure added sales appeal by equipping with Modine Radiators.

MODINE
SPIREX and TUBULAR
RADIATORS

Write for Modine Booklet

Modine Manufacturing Co.
Racine, Wisconsin

Cushman 8 H. P. Unit Power Plant Equipped with Modine Spirex Radiators

NOTES AND REVIEWS

Continued

are said to be three: to increase the speed of racing cars, to give to the ordinary passenger-car added flexibility and, possibly, to bring to the fore the two-cycle engine.

The article closes with a detailed description of the Root blower type of supercharger and the exhaust-driven and the mechanically driven centrifugal types.

Weight—and Its Distribution. By W. F. Bradley. Published in *The Autocar*, June 5, 1925, p. 981.

An analysis is made of the distribution of weight in an English-make light passenger-car. The method of carrying on the investigation is described, and comparisons are drawn between the useful load or that necessary for the actual operation of the car and the non-useful load or that provided only for the comfort of the passengers. The author also gives examples of the relation between weight and manufacturing costs and advances suggestions for making cars lighter. The weight of the component parts of an automobile are discussed in connection with the value of the work they perform.

The weight of the car in question with a fabric closed body is 2046 lb., with an open body, 1894 lb. In the closed body, weighing 961 lb., 65.3 per cent is given over to the body proper; with the mudguards, running-boards, spare wheel and support, and accessories amounting to 34.7 per cent. The main items in the chassis weight of 1085 lb. are: the engine, 334 lb.; wheels and tires, 155 lb.; rear axle, 134 lb.; frame, 126 lb. and front axle, 88 lb.

Notes on Professor Lemaire's Visit and Lectures, with Supplementary Data. By G. B. Upton. Published in *The Sibley Journal of Engineering*, June, 1925, p. 353.

A summary is made of the lectures delivered at Cornell University by Prof. Pierre Lemaire, exchange professor of the University of Lyons, on spring-suspension and what constitutes riding-comfort. Professor Lemaire is said to have attacked the problem first as a physiological one, setting up a seat on a platform which could be driven in an harmonic vertical oscillation and testing some 300 people on that seat. From these tests he found what motions, as to amplitude, frequency, acceleration and so forth are pleasant or unpleasant. His conclusion is that the feeling of comfort or discomfort depends upon the accelerations of the vibrations—and most precisely on the time rate of variation and acceleration. Next he took up the general problem of the oscillations of the vehicle and its axles on the tires and springs, giving to this topic a thorough mathematical analysis as a kinematic problem. Four sets of double frequencies of the natural vibrations of the chassis were found.

Professor Lemaire's instruments for measuring the accelerations and variations of accelerations on a car on the road are described. Tables are then given to show the probable range of riding-comfort. The figures used in building-up the tables are the result of applying data obtained by experiments in this Country to Professor Lemaire's formula for riding-comfort.

A New Six-Cylinder Bentley. Published in *The Autocar*, June 19, 1925, p. 1075.

The specifications of the new Bentley car are:

Engine.—Six-cylinder, 100 x 140 mm. (3.937 x 5.512 in.), 6597 cc. (402.524 cu. in.), 24 overhead valves, overhead camshaft with connecting-rod drive, twin-magneto ignition

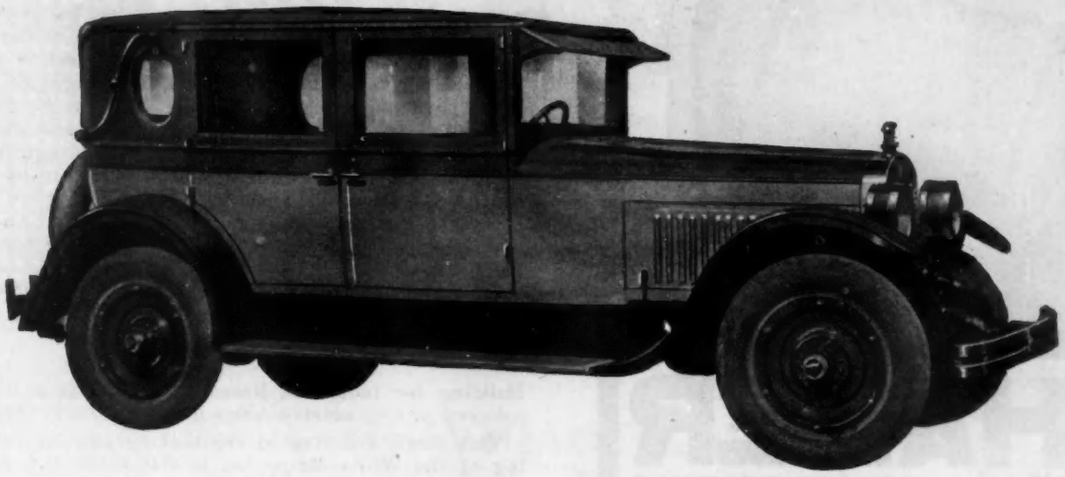
Springing.—Half-elliptic springs

Transmission.—Four-speed and reverse gearbox, separate from engine

Wheels.—Detachable wire wheels with 33.00 x 6.75 in. tires

Brakes.—On all four wheels

(*Continued on p.* 16)



Anderson Body in Egyptian

Hudson Chassis

THROUGH the courtesy of the Anderson Body Company of Sidney, Ohio, we show the above illustration of one of the models of their manufacture finished in Egyptian Automobile Finish

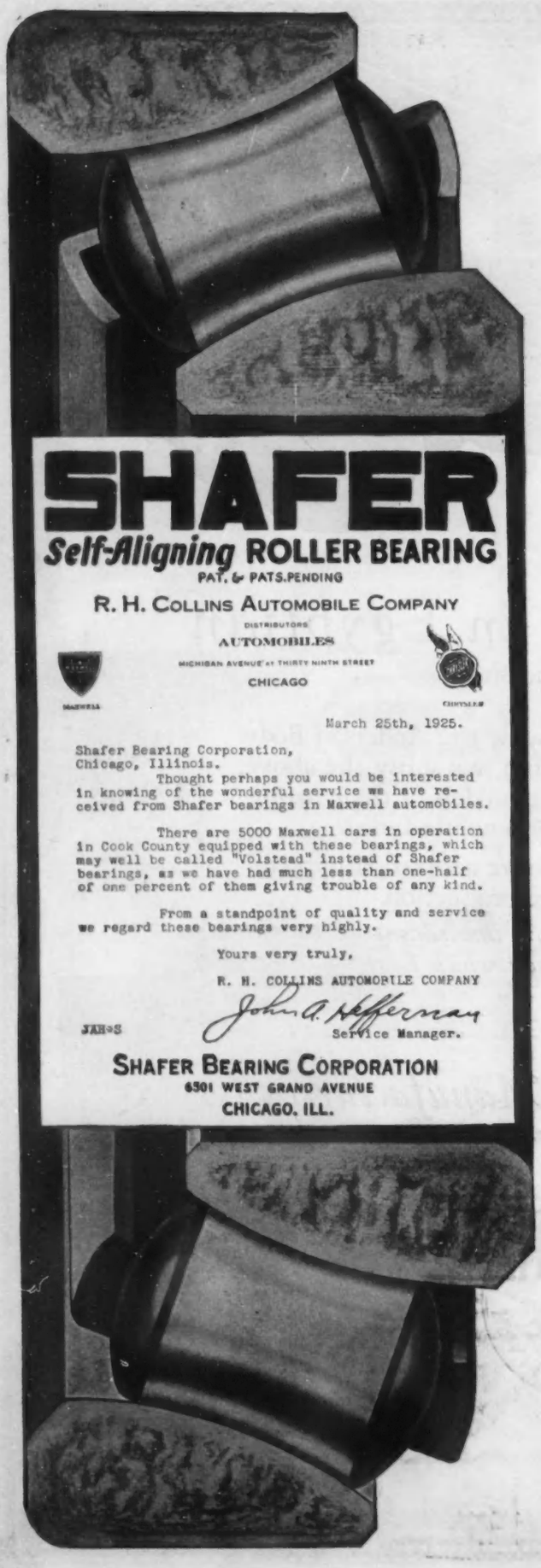
The Anderson Body Company have adopted "Egyptian" as standard finish on their entire production.

In additional ads we hope to show illustrations of various other models of motor car bodies upon which Egyptian Automobile Finish is used exclusively.

The Egyptian Lacquer Manufacturing Co.

90 West Street, New York

EGYPTIAN AUTOMOBILE FINISH


SHAFER
Self-Aligning ROLLER BEARING
PAT. & PATS. PENDING
R. H. COLLINS AUTOMOBILE COMPANY
DISTRIBUTORS
AUTOMOBILES
MICHIGAN AVENUE at THIRTY NINTH STREET
CHICAGO
March 25th, 1925.
Shafer Bearing Corporation,
Chicago, Illinois.
Thought perhaps you would be interested in knowing of the wonderful service we have received from Shafer bearings in Maxwell automobiles.
There are 5000 Maxwell cars in operation in Cook County equipped with these bearings, which may well be called "Volstead" instead of Shafer bearings, as we have had much less than one-half of one percent of them giving trouble of any kind.
From a standpoint of quality and service we regard these bearings very highly.
Yours very truly,
R. H. COLLINS AUTOMOBILE COMPANY
JAH:S
Service Manager.
SHAFER BEARING CORPORATION
6301 WEST GRAND AVENUE
CHICAGO, ILL.

NOTES AND REVIEWS

Continued

Several novel features are said to be incorporated in the chassis design. The crankshaft has eight bearings, a damper at the forward end and the camshaft drive at the rear. The camshaft drive is in a tunnel, and in connection with its design the normal train of gears has been discarded in favor of three connecting-rods. A number of damping devices have been provided for in the chassis. The camshaft drives the water pump at one end and the dynamo through fabric joints at the other, so that the irregularities set-up by the action of the valves are damped out. Oil is supplied to all the bearings under pressure from a gear pump. Each cylinder is surrounded with water and is cast in one piece with its head, while the water surrounds also the head and exhaust ports. A new type of clutch has been adopted, and the steering-gear has been redesigned for the use of low-pressure tires.

Building for Industrial Research and Testing Work. Published in *Engineering News-Record*, June 25, 1925, p. 1056.

This newly constructed engineering and laboratory building of the White Motor Co. is 150 x 160 ft. A one-story portion of the building, 110 ft. wide, is divided into two equal parts to provide for the engineering research laboratories and a machine shop for experimental and research work. The other section of the building, 40 x 160 ft., is a two-story structure, on the first floor of which are the engineering and metallurgical offices, physical testing-room, chemical laboratory and microscope-rooms. A design department occupies the whole second floor.

About six dynamometers can be installed on the testing-floor for testing engines, axles, transmissions and other parts or mechanisms. The total cost of the building, including equipment, was nearly $300,000 and 100 men are employed in the research work carried on there.

Power Presses—Their Use in Industry. By E. V. Crane. Published in *Forging-Stamping-Heat Treating*, June, 1925, p. 213.

Engineers and designers, according to this article, should become familiar with power presses, so that better and more economical production can be brought about. In emphasizing the importance of power presses to the automotive industry, the author points out that blanking and drawing, forming or stretching methods are now employed to produce heavy side-rails and cross-frame members, cowl, body and door parts, crankcases, fenders, hubs, axle housings for even the heaviest truck, disc wheels, radiator shells and brake-drums. Hot-forming and press-forging methods are being used on step hangers, pinion blanks, trim hardware, valve heads and miscellaneous small forged parts. Instead of milling many parts, manufacturers are now using knuckle-joint type of presses to squeeze the cleaned forgings accurately to size. Caps, lamps, tanks, bushings, covers and many small electrical parts are also press produced.

The author then classifies the different basic methods for press-working metals according to the stress, shearing, tensile or compressive, they create in the metal. Examples are cited of processes under each of these heads, and practical suggestions are given as to the best methods of operation.

Drilling Machines of Unusual Design. Published in *Machinery*, June, 1925, p. 785.

The use of special drilling machines for certain operations instead of standard tools is said to be of particular interest to the automobile industry for low production-costs must be maintained in this field. Then, too, in most automobile plants the quantity of parts of one kind produced is sufficient to keep special machines busy.

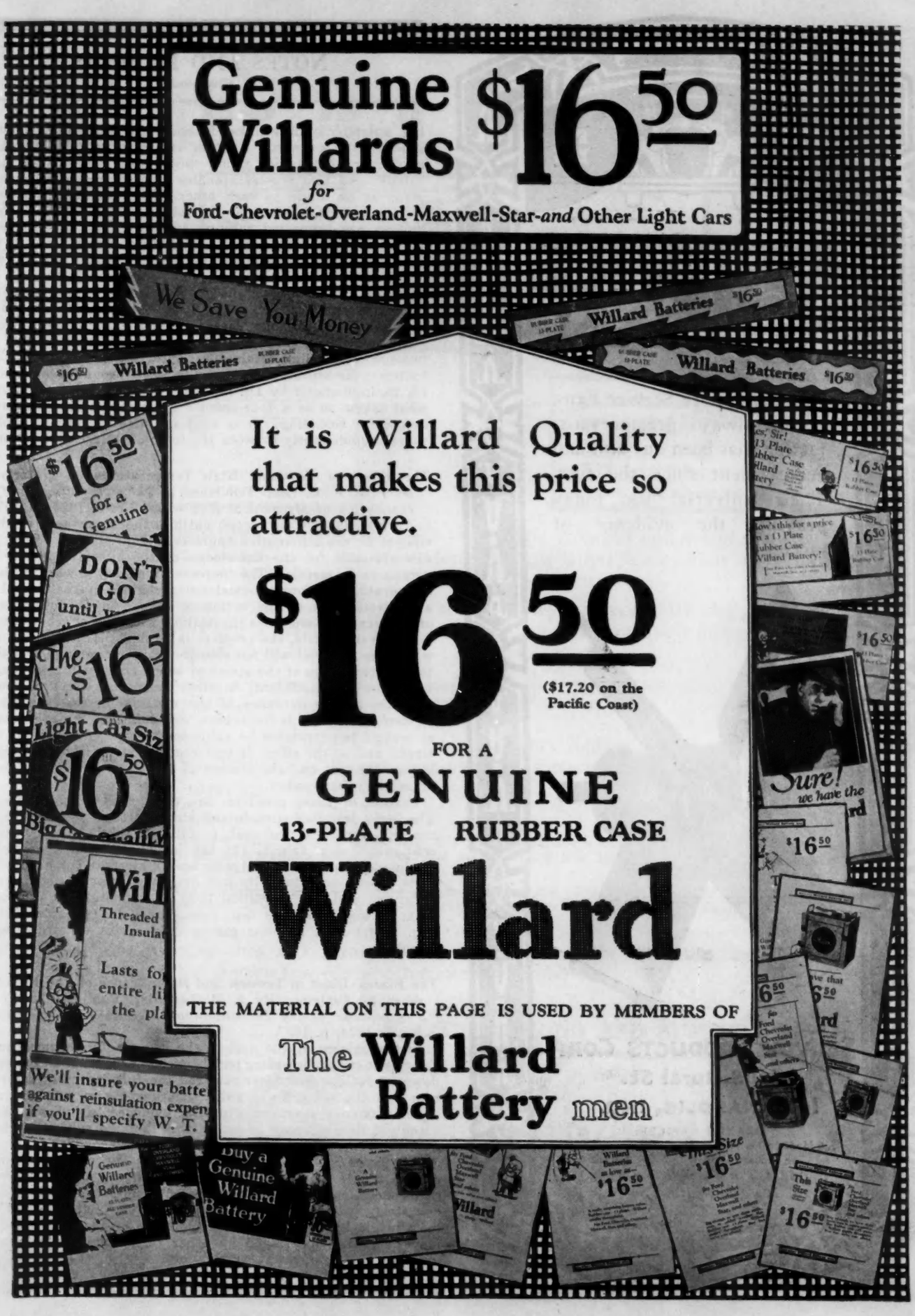
Several special drilling-machines for use on automobile parts are described and illustrated. One machine, for drill-

(*Continued on p.* 18)

Genuine Willards $16.50

for

Ford-Chevrolet-Overland-Maxwell-Star-*and* Other Light Cars



It is Willard Quality that makes this price so attractive.

$16.50

($17.20 on the Pacific Coast)

FOR A

GENUINE

13-PLATE RUBBER CASE

Willard

THE MATERIAL ON THIS PAGE IS USED BY MEMBERS OF

The Willard Battery men

SERVICE
FLOOD OILING
FAN
More and more Service Fans, giving always greater satisfaction, has been our aim and achievement since the first. Their universal use today provides the evidence of success.
SERVICE PRODUCTS CORP.
201 S. Rural St.
INDIANAPOLIS, IND.
BRANCH OFFICES:
526 Madison Terminal Bldg. Chicago
205 Kresge Bldg., Detroit
"If It's a Flood-Oiling Fan It's a SERVICE Fan"

NOTES AND REVIEWS

Continued

ing automobile drag-links, is equipped with four spindles spaced 90 deg. apart. Another is a standard single-spindle machine equipped with a four-spindle drill head on the main spindle and two special spindles located in the horizontal plane at an angle to each other. The two last-mentioned spindle units are driven by individual motors, and their feed pinions are connected through telescopic shafts, universal-joints and bevel gears to the standard power feed of the machine. Four drills in the multiple head and one in each of the two table spindles are fed simultaneously to drill six holes in a transmission plate. A third is a light machine with two spindles for drilling six smoke holes around a piston. Three oil-holes located at different angles in one plane are drilled in a crankcase by another machine. A two-spindle machine is also described, which, by an unusual fixture drills 216 holes, ⅛ in. in diameter around a piece only 1¾ in. in diameter by 1¼ in. long. The final piece of equipment taken up is a four-spindle machine that is automatic except for reloading. It is used for drilling three oil-holes spaced equidistantly between the teeth of differential pinions.

The Effect of Low and High Temperatures on Materials. By Prof. F. C. Lea. Published in *The Proceedings of the Institution of Mechanical Engineers*, No. 6, 1924, p. 1053.

An introductory paragraph outlines the importance of this subject to the automotive engineer. High-altitude flying of aircraft calls for the knowledge of the effect of low temperatures on metals. The increased tendency toward higher temperatures in internal-combustion engines makes desirable an investigation of the action of metals at the other end of the scale. Sometimes, in dealing with the effect of temperature on metals, the problem is to find the safe stress at which the material will not change form or creep; sometimes the determination of the stress at which creep will take place very slowly is sufficient; in other cases the effect of temperature on the hardness of the material or its resistance to change of form is important; or again, the material may at certain temperatures be subjected to rapid fluctuations of stress, and so the effect of temperature on the range of repetition stresses and the change in elastic properties become of primary importance.

Certain of these problems are dealt with in this paper. The tests described include (*a*) static tests at temperatures ranging from —80 deg. cent. (—112 deg. fahr.), to 1000 deg. cent. (1832 deg. fahr.), (*b*) the investigation of the effect of time upon metals loaded with known stresses (*c*) hardness tests determined statically and dynamically at various temperatures and (*d*) repetition tests at temperatures varying from 15 deg. cent. (59 deg. fahr.) to 800 deg. cent. (1472 deg. fahr.) in a machine giving 2000 cycles of stress per minute.

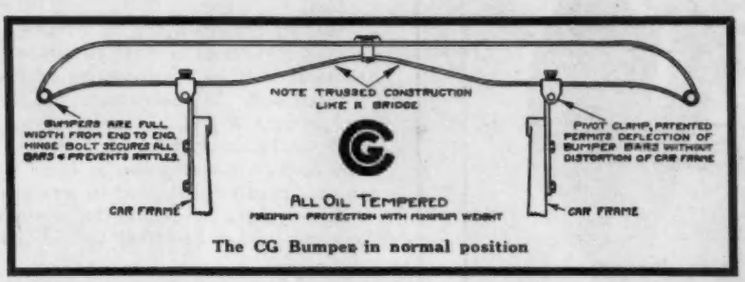
The Elastic-Limit in Tension and Its Influence on the Breakdown by Fatigue. By J. M. Lessells. Published in *The Proceedings of the Institution of Mechanical Engineers*, No. 6, 1924, p. 1097.

In the opinion of the author, the degree of influence that the elastic properties of materials exert on their actual breakdown by fatigue has never received the full degree of attention that the subject warrants. His purpose in writing the paper was to present experimental evidence to indicate the extent of this influence in such a way that the subject might be easily understood by the designing engineer.

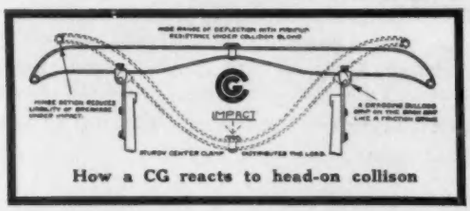
The paper is divided into five sections; apparatus, method of procedure, tension and fatigue, endurance by deflection and conclusions. The first series of results are applied to one steel, and the second to various ferrous materials. All metallurgical terms have been omitted, so that the paper may be easily understood by other than metallurgical engineers.

(*Continued on p. 22*)

Why CG is a *Good* Bumper


NOTE TRUSSED CONSTRUCTION LIKE A BRIDGE
BUMPERS ARE FULL WIDTH FROM END TO END. HINGE BOLT SECURES ALL BARS & PREVENTS RATTLES.
PIVOT CLAMP, PATENTED PERMITS DEFLECTION OF BUMPER BARS WITHOUT DISTORTION OF CAR FRAME
CAR FRAME
ALL OIL TEMPERED
CAR FRAME

The CG Bumper in normal position



How a CG reacts to head-on collison

How a CG deflects side collisions

Don't judge a bumper by appearance only—or by the strength and weight of materials used. Ability to *absorb collision shocks* determines whether it's a really good bumper.

CG Spring Bumpers are *good* bumpers because they are correctly designed and engineered to withstand a maximum of collision impact from any angle and to pass a minimum of shock through to the car.

A CG in collision acts like a fireman's net in a leap from a window—it absorbs impact gradually and harmlessly, through spring action.

The diagrams above show clearly how CG Bumpers deflect the shock of collisions. Study them. See how a CG brings your car to a stop with the least chance of personal or mechanical injury.

1—This illustration shows the detailed construction of a CG Bumper.

2—The dotted lines show what happens when your CG Bumper strikes a telephone pole or a water plug—excepting that it takes an enormous force to bend the bumper back that far and, in every inch of this movement, your car is gradually coming to a stop.

3—Should you strike another car or a stationary object with the end of your CG Bumper, note how the front bars collapse gradually against the back bar—absorbing most of the blow. All of the bumper assists in cushioning a collision.

Is it any wonder that CG Bumpers are now used more than any other one make—more than all but a very few of the other makes combined?

THE C. G. SPRING AND BUMPER COMPANY
2660 EAST GRAND BOULEVARD, DETROIT
New York Cleveland Chicago

CG *oil tempered*
BUMPERS

The MAKING OF MALLEABLE

A New Book by

Wanner

THE making of malleable is treated in a simple and concise manner in this brochure—recently off the press. Certain exclusive features are referred to; but in the main, its object is to indicate the broad field of malleable, and to eliminate the highly technical data that confuses rather than enlightens the layman. We will be glad to send it upon request. If more convenient, use the coupon for this purpose.

WANNER MALLEABLE CASTINGS CO.
Hammond, Indiana

Send your new book to the undersigned:

Name_____

Firm _____

Street Address _____

City_____ State _____

Plants:
Hammond, Indiana
Beloit, Wisconsin

NOTES AND REVIEWS

Continued

A Basis for Analyzing Revenues and Expenses. By Carl W. Stocks. Published in *Bus Transportation*, June, 1925, p. 267.

A full classification of revenue and expense accounts for the operation of a fleet of motorcoaches is given. In subsequent articles, the details of the accounting plan will be worked out. In the present article, comments are invited in the hope that, with constructive criticism, a comprehensive and workable system of accounting for this branch of the automotive industry can be built up. The outline is arranged so that it can be adapted to any one of three classes of motorcoach system according to annual earning power; $500,000 or more, from $100,000 to $500,000 and less than $100,000.

The Future of the Motorbus. By John A. Ritchie. Published in *Bus Transportation*, May, 1925, p. 229.

The progress of motorcoach transportation since 1917 is summarized, and comparisons with that of other passenger carriers are made. Following are some of the statistics given.

CLASSIFICATION OF MOTORCOACHES IN OPERATION IN 1924

Regular Passenger	34,500
School	20,000
Sightseeing	1,500
Hotel	1,000
Miscellaneous	5,000
Total	62,000

TAXICABS

Number of Taxicabs in Service in 1924	66,000
Number of Companies Operating	1,680
Number of Independents	21,000
Cab Miles Operated Last Year	1,780,000,000
Passengers Accommodated Last Year	592,000,000

An estimate is made that within the next six years a total of 272,000 motorcoaches will be in operation in this Country.

Turnbuckle Framing and Rear Passenger-Exit Are Features of California City-Type Body. Published in *Bus Transportation*, May, 1925, p. 232.

A special type of spring-suspension put on 46 B. & H. motorcoaches at Long Beach, Cal., last summer is being made standard equipment for all the vehicles operated by this line. The advantage claimed for the suspension is that it eliminates torque and twisting of the frame and thus reduces wear on many units. According to the report, cylinders remain true, and clutch and transmission, bearings and tires show less wear than with a rigid frame on the same run.

No nails are used in the body construction. Bolts with spring lock-washers are put in, and the nuts are accessible so that they can be tightened up when wear makes it necessary. Another unusual feature is a strip of iron screwed around the top of the body frame. It serves as a combination gutter and bumper for the prevention of scraping along the top.

Much New Legislation. By Kenneth L. McKee. Published in *Aera*, June, 1925, p. 1824.

A summary of laws of interest to the electric railway industry, passed by 41 State legislatures since Jan. 1 of this year, is made. Included are many new regulations affecting motor vehicles. For instance, several 1925 legislatures granted to electric and steam railways the privilege of operating motorcoaches. The number of States in which a state regulatory commission has jurisdiction over motor-vehicle common carriers has been increased from 32 to 40. Seven States enacted a gasoline tax, and several increased the amount of this tax.

The article also includes a table showing the State bodies having jurisdiction over motor carriers and the extent of this jurisdiction.

(*Continued on p.* 24)

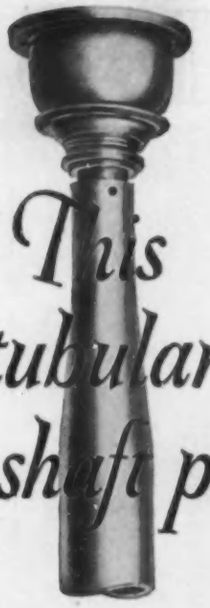
SMITH FRAMES

Smith MILWAUKEE

MEN who own several cars usually know least about them—but their demand for sturdiness and quiet, trouble-free travel has had much bearing on the thought given modern frame design. It is not a coincidence that the world's better cars have the best frames!

A. O. SMITH CORPORATION · MILWAUKEE, WISCONSIN

DETROIT OFFICE: GENERAL MOTORS BLDG.



This tubular shaft prevents "whip"

SPICER, pioneer of the principle of the shaft drive, also introduced the first tubular shaft, to prevent "shaft whip," when fine roads encouraged the building of faster cars.

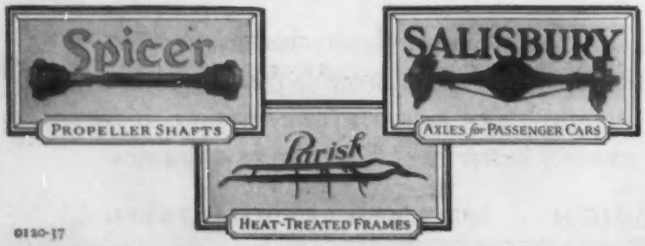
With the present vogue of the high speed closed car, a smooth-running propeller shaft becomes doubly important because closed models tend to magnify every sound of mechanical vibration.

The quietness of the Spicer propeller shaft is due to:

1. The dynamic balance of the design [smooth-running].
2. Accuracy of parts, checked at every stage [no lost motion].
3. Tubular shafts of proper size [no critical vibration].
4. Final inspection of the assembly for silence.

Associated **Spicer** *Companies*

Spicer Manufacturing Corporation, South Plainfield, N. J.
Parish Manufacturing Corporation, Reading, Pa.
Salisbury Axle Company, Jamestown, N.Y.



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NOTES AND REVIEWS

Continued

Alcohol Motor-Fuel from Molasses. By E. C. Freeland. Published in *Industrial and Engineering Chemistry*, June, 1925, p. 615.

This paper contains a general discussion of the equipment needed, the methods of manufacture, yields and cost data of producing alcohol and alcohol-ether motor-fuels from cane molasses. Among the reasons for the development of alcohol as a motor-fuel are given the rapid decrease in the world's supply of crude petroleum, the occasional scarcity of gasoline and the high cost of motor-fuel in foreign countries.

In describing the quality of alcohol to be used for fuel purposes, the author stipulates that it should contain only a small quantity of impurities that will cause corrosion, such as acids and esters, and especially fusel oils. The strength of the alcohol should be at least 95 per cent by volume. Regarding the results and costs of manufacture, the author points out that the yield of absolute alcohol per 100 lb. of fermentable sugar varies from 2.9 to 6.9 gal., according to the type of fermentation used. Figures are then given which show that the equipment to convert into motor-fuel the entire amount of molasses produced from 1000 tons of cane per day would cost $120,000. According to a further analysis, the quantity of an alcohol fuel which would equal in motive power 1 gal. of gasoline would entail manufacturing costs of from 20.1 to 36.6 cents.

The Estimation of Airplane Performance from Wind-Tunnel Tests on Conventional Airplane Models. By Edward P. Warner and Shatswell Ober. National Advisory Committee for Aeronautics Technical Note No. 218. Published by National Advisory Committee for Aeronautics, City of Washington, 18 pp.

Wind-tunnel models of complete airplanes are commonly used for the prediction of balance, stability and control characteristics. Attempts to forecast performance characteristics directly from the same tunnel tests have been infrequent, due to the several obvious sources of error in such calculations. Still, according to the authors, the total error is likely to be a function of a general type of airplane. The ratios between the performance so calculated and that actually obtained on a flight test will lie within a comparatively narrow range for all airplanes of a generally similar type.

The paper then gives some of the results of a series of performance calculations made at the Massachusetts Institute of Technology in the last 4 years. Calculated performances are compared with those actually determined on test flights. The elements of performance include the maximum and the minimum speed, absolute ceiling and the rate of climb at sea level. From the results obtained, the conclusion is drawn that, if carefully applied, the model test should make possible predictions of performance that are more accurate than the result secured from any formula and should not compare unfavorably in its results with computation by the usual process of the summation of partial drags.

Determination of Turning Characteristics of an Airship by a Camera Obscura. By J. W. Crowley, Jr., and R. G. Freeman. National Advisory Committee for Aeronautics Report No. 208. Published by National Advisory Committee for Aeronautics, City of Washington. 8 pp.

This investigation was carried out at Langley Field to determine the adaptability of the camera obscura to the securing of turning characteristics of airships, and also to obtain some of these characteristics of the C-7 airship. The method consisted in flying the airship in circling flight over a camera obscura and photographng it at known time-intervals. The results are said to show that the method used is highly satisfactory and that for the particular maneuver employed the turning diameter is 1240 ft., corresponding to

(*Continued on p.* 26)

Good bye, buggy wheels

Here at last is a wheel that looks.. ..acts..says *"Automobile"*

THOSE first motor cars—back in the dear dead days of mutton-leg sleeves and mustache cups—those first gasoline buggies sometimes kicked up a cloud of dust . . .

But you wouldn't call them *automobiles!*

They were everything that an automobile ought not to be. There is scarcely a detail of the engine, frame, body, or top of the modern motor car which has not been refined beyond all resemblance to its ancient counterpart. And yet . . . and yet . . .

The *wheels* of those one-lungers were practically identical with the wheels on which many an otherwise distinguished automobile is getting around today!

A great engineer decided to build a wheel in keeping with the looks, speed, weight, of the modern motor car . . . an *automobile* wheel.

He naturally selected the material which makes possible the other parts of the car—*steel.*

He studied the stresses which a man-size motor car meets when it goes some place. He created a design to absorb these stresses.

He built the only *convex* wheel—a form which utilizes the natural resilience of steel to the utmost, to save the chassis from road shocks—a form which permits the placing of brakes and king pins *within* the wheel, for more positive braking and easier steering . . . for better protection of brakes from mud and water . . .

He built a *demountable* wheel, hiding the brakes but making them immediately accessible when adjustment is necessary . . .

He built a lighter and stronger wheel—stream-lined like the car . . .

He built a wheel that looks—acts—says "Automobile"—the Budd-Michelin Wheel!

Other steel wheels have come along—the sincerest form of flattery. But they can't have the exclusive design or exclusive features which make the Budd-Michelin Wheel—a Budd-Michelin.

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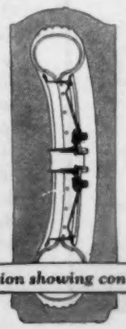
BUDD-MICHELIN—*the All-Steel Wheel gives you these advantages:*

—a scientific convex form, increasing resilience, and permitting the placing of brakes and king pins *within* the wheel, for better braking and easier steering—for greater protection of brakes from mud and water



Cross-section showing convex design

—a demountable wheel which hides the brakes but gives immediate access to them when adjustments are needed.

—a light wheel (lighter than wood) tapering toward the rim, making starting and stopping easier

—five wheels to a set. An extra wheel to dress up the rear of the car, easy to substitute in case of tire trouble. No rims to remove

—everlasting strength, promoting safety. Triumphant beauty.

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These are the qualifications that are responsible for the continued and growing use of MECHANICS Transmissions, and other Products, and that give them their popularity and good name with both car builder and user.

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4222 Woodward Avenue

NOTES AND REVIEWS

Continued

a turning coefficient of 6.4, and that the position of zero angle of yaw is at the nose of the airship.

Stability Equations for Airship Hulls. By A. F. Zahm. National Advisory Committee for Aeronautics Report No. 212. Published by National Advisory Committee for Aeronautics, City of Washington, 5 pp.

In this paper are derived simple formulas for determining, directly from the data of wind-tunnel tests of a model of an airship hull, what shall be the approximate character of oscillation, in pitch or yaw, of the full-scale ship when slightly disturbed from steady forward motion.

Nonmetallic Diaphragms for Instruments. By H. N. Eaton and C. T. Buckingham. National Advisory Committee for Aeronautics Report No. 206. Published by National Advisory Committee for Aeronautics, City of Washington. 44 pp.

This report is the second of a series of reports on instrument diaphragms. The first was published as Technical Report No. 165 on Diaphragms for Aeronautic Instruments, and comprised an outline of historical developments and theoretical principles with a discussion of expedients for making the best use of existing diaphragms.

The present report relates entirely to nonmetallic diaphragms that for some time have been used increasingly in certain types of pressure elements. Little information has been available, however, to aid the designer of instruments using this form of pressure element. The investigation reported in this paper was made in an attempt to meet the need for such information.

The report describes the various materials that have been used as nonmetallic diaphragms, discusses the factors that affect the performance of the diaphragms and gives the results of tests made to determine the effect produced by these factors. A theoretical discussion is given in which a demonstration is made that the effective area of a nonmetallic diaphragm can be computed for specified conditions and hence the pressure-deflection curve can be predicted. Curves are given to facilitate the computation of effective areas under any set conditions. The theory, tested experimentally, was found accurate within about 5 per cent. Finally pressure-deflection curves are plotted to illustrate the control that the designer has over the shape of the curve by varying the different parts of the pressure element.

Some Recent Work of the Aerodynamics Department, National Physical Laboratory. By R. V. Southwell, *The Journal of the Royal Aeronautical Society*, April, 1925, p. 146.

The period covered is from 1920 to the present, and only methods, not results, are discussed. The development of the Duplex tunnel, and its use in measuring lateral stability derivatives of an SE5A model are explained. By the end of 1922, complete data on lateral stability characteristics of this type were said to be available for the first time. The "three force and three moment" apparatus for non-rotary derivatives is described. By its use and by oscillation experiments carried on in 1923 and 1924, the complete data in regard to lateral stability for the Bristol Fighter model were ascertained. The stage has just been reached, concludes this section, at which for the first time stability data with allowance for slip-stream effects can be obtained on a model.

Under performance, most of the work was aimed at the elucidation of scale-effect. Recent investigation of propellers had for its purpose testing the consequences of the vortex theory presented by Mr. Glauert in 1922. Very little experimentation had been done with airships since the accident to the R 38 in her trial flight in August, 1921.

(*Continued on p.* 28)

Oiliness in Oil

You can recall when "Oiliness" was a laboratory curiosity. This term is now understood to be a recognized practical requisite of motor oil.

Oiliness in a lubricant is that quality which reduces friction at a time when the oil film is imperfect. It also reduces frictional loss at the starting motion from rest.

In an automobile engine each piston stops and restarts twice each revolution. Also when an engine has stood idle there is an appreciable lapse of time, after starting, before the many oil films are built up.

Good oiliness gives protection during the critical time immediately after starting. It also reduces piston friction.

Sunoco Motor Oil is unique; it is high in "oiliness" without being blended with animal or vegetable substance. Its constant use insures the minimum of wear and of frictional loss.

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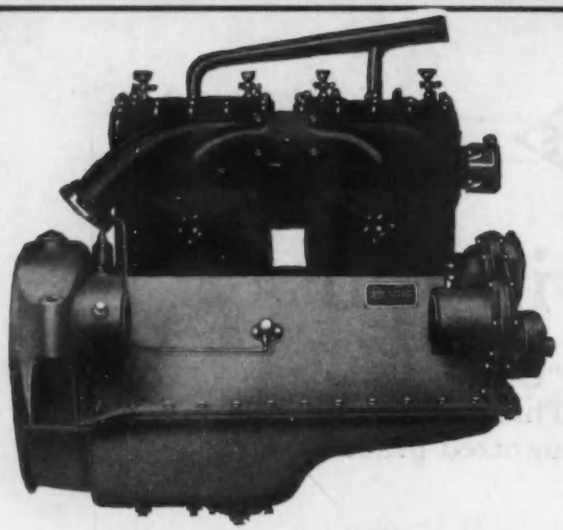

To Our Customers

With our plant at record speed, and with a swelling stream of orders assuring full future activity, we take this opportunity to congratulate our customers, whose prosperity is the direct source of our own activity and success.

To the builders of Hinkley-Engined Trucks and Tractors, and to those manufacturers in other fields of Transportation and Industry, whom we similarly serve, we extend good wishes and appreciation.

They have taken our product into the highways and byways of the world, and have made it famous as a faithful, long-lived, well built piece of heavy-duty machinery. They have made it part and parcel of their sales message to millions. For it they have developed a market which today surpasses expectation.

We admit frankly a combined sense of Pride and Obligation—pride in our ability to help these customers forward by furnishing them with good Engines; Obligation to continue unwaveringly to build the Best We Know.

Expanding facilities will enable us to fill within a few months, orders from a limited number of additional customers. May we submit prices?

	Bore	Stroke		Bore	Stroke
Model 300—	3¾″	x 5¼″	Model 100	4¾″	x 6″
Model 400—	4″	x 5¼″	Model 1900	5½″	x 6″
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NOTES AND REVIEWS

Continued

Under fundamentals of fluid motion, the checking of the Prandl theory is listed as one of the chief problems. Studies of eddies have been made with hot-wire instruments. The use of the latter in conjunction with selective resonators is recommended for experimental attack on the problems of "boundary layer." Elastic vibration has received considerable attention. One project of great experimental difficulty has been the effort to trace existing noises in propellers to their sources.

In closing, the author endorses the more theoretical type of research as most likely to lead to true progress, and makes a plea for freedom and leisure for the individual worker, which alone makes such research in ideas possible.

Commercial Aviation Now Possible and Probable. By J. G. Vincent. Published in *The Automotive Manufacturer*, May, 1925, p. 5.

In summing up the progress of aviation in the last 10 years, the author points out that during this time the airplane's maximum speed has grown from 100 to 270 m.p.h., the maximum-non-stop duration of flight from 24 to 37 hr., the maximum altitude from 20,000 to 36,000 ft. and the largest engine unit from 200 to 1000 hp. Lighter-than-air development has not been so great, due to the greater expense of this type and its non-availability for war purposes rather than to its lack of usefulness. Airplanes have not yet reached the stage of perfection, says the author, where they can compete economically with other means of transportation and he voices the opinion that the very latest airplane today is only "a very crude article."

The article then shows in detail how engineering effort in connection with aircraft engines is now being concentrated on improving the following four characteristics: reliability and durability, light weight, high power for small displacement and economy in operation and maintenance. The author explains how airship requirements for reliability, durability and economy in powerplants are more pressing than the need for similar characteristics in airplane engines. The prophecy is made that within the next few years airplane engines will weigh about 1 lb. per hp. and will be as durable as the best automobile engines.

The article closes with a discussion on the progress in airplane design, which has been in two directions, the reduction of maintenance and costs by simplifying structure and increasing speed by lowering the head resistance of the complete airplane.

The Rigid Airship. By E. H. Lewitt. Published by Isaac Pitman & Sons, Ltd., London. 283 pp.; 135 illustrations.

This book, which is believed to be the first complete work on the subject published, incorporates the results of the author's experience in the design of the rigid airship. It is intended for the use of designers and aeronautical students, and the treatment is based on the assumption that the reader has a knowledge of engineering principles up to the standard of a university degree. Only structural design and performance are included in the subject matter; no attempt has been made to deal with engines and machinery.

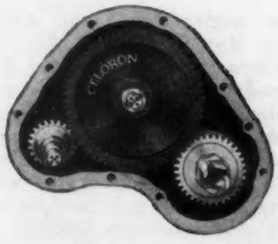
The subject has been approached from the point of view of a practical engineer. The mathematics have been kept as simple as possible throughout, and all theoretical deductions have been compared with practical experience. Many new problems arose in connection with the design of an airship structure, and these have been exhaustively dealt with. One of new problems specified was the determination of the beam stresses in a short braced tube and the forces in a wire diaphragm due to a lateral pressure.

Some of the subjects treated are: the development of the airship; aerostatic, dynamic and static problems; tests on girders, struts and materials used in the structure; beam

(*Continued on p. 30*)

More and more automobile manufacturers are adding to the life of their cars with Celoron Silent Timing Gears

THE list grows larger steadily, and today more than a million passenger cars are protected from the unfortunate consequences of worn timing gears.



A Celoron Silent Timing Gear properly mated with metal gears insures the continuance of correct and silent timing, adds to the efficient life of the car and to its economical operation.

Such pronounced endorsements indicate that car makers realize the public's increasing knowledge of the benefits of long-wearing, noiseless timing gears and are adopting a sales asset of growing importance.

Diamond Fibre is used in many places in cars and trucks for gaskets, bushings, washers and insulation.

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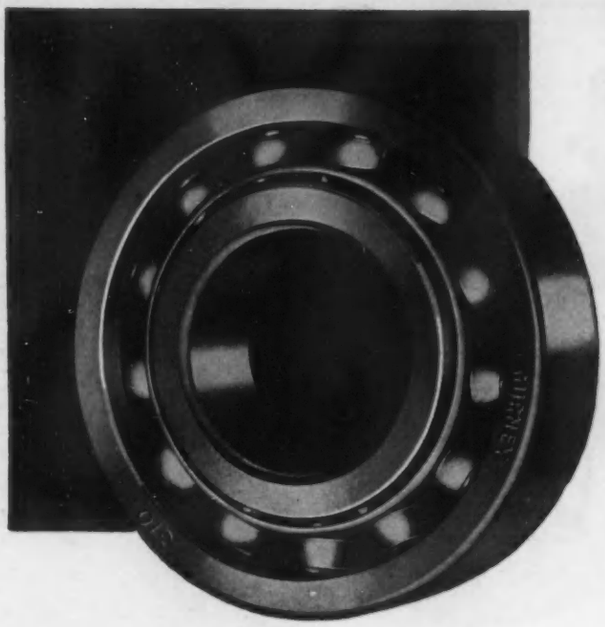

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The strength of Gurney Ball Bearings, Maximum Service—Maximum Capacity type, is made possible by using more and larger balls than are used in equivalent sizes of any other type of bearing. The load carrying capacity is therefore surpassed by none, but the factor of safety and length of service is far greater than in other bearings. Gurney Maximum Service—Maximum Capacity Ball Bearings are best suited where heavy loads and extremely hard service are encountered.

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NOTES AND REVIEWS

Continued

stresses and temperature stresses on the hull; the detail design of the various structural members of the airship; a general equation for the weight of an airship hull and a complete, worked-out example on the design of a large airship.

The 1000-Hp. Rumpler Aircraft Engine. Published in *The Automobile Engineer*, June, 1925, p. 170.

The Rumpler engine is a combination of the straight and radial types, consisting of four radial banks of seven cylinders each. Each cylinder has a bore and stroke of 140 x 140 mm. (5.51 x 5.51 in.), giving a total cubic capacity for the 28 cylinders of 60,343 cc. (3681.93 cu. in.). Assuming a mean effective pressure of 7.5 atmospheres at 2000 r.p.m., the output would be about 1000 hp. The overall length and diameter of the Rumpler engine is 1600 x 1210 mm. (62.99 x 47.64 in.)

A detailed description is given of the engine, of which the following are some of the points. The crankshaft is of nickel-chrome steel and is carried in five bearings. Seven connecting-rods are arranged around each crankpin. Particular interest attaches to the special aluminum alloy crankcase, built of four sections bolted together.

On the rear radial engine every cylinder is formed with a rectangular pocket that houses the push-rods of the corresponding row of cylinders. Each linear row of four cylinders is connected by a common detachable cylinder-head. Two inlet and two exhaust-valves, each having a throat diameter of 52 mm. (2.05 in.) are fitted per cylinder, the 112 valves being operated in a simple manner by four centrally arranged cam discs.

The centrifugal water-pump is driven by a short shaft forming the direct extension of the rear crankshaft end, to which it is attached by taper, key and nut. The oil-pump is driven by an eccentric formed on an extension of the intermediary timing-gear hub. Two independent magnetos are provided, driven by a bevel gear on the rear crankshaft extension. An epicyclic gear is used for the reduction between the engine and propeller shaft.

A summary of the arguments advanced by Dr. Rumpler in favor of his design as opposed to other layouts concludes the article.

60-Hp. Cirrus Engine for Light Airplanes. Published in *Engineering*, May 8, 1925, p. 572.

The new Cirrus engine, intended for use on school or privately owned light airplanes, has an R. A. C. rating of 27.3 hp., develops 60.0 hp. at its normal speed of 1800 r.p.m., or a maximum of 65.0 hp. at 2000 r.p.m. It is of the four-cylinder, air-cooled type with the cylinders mounted on the crankcase in a single row after the manner of an ordinary automobile engine. The cylinders have a bore of 105 mm. (4.13 in.) and a piston stroke of 130 mm. (5.13 in.). The total weight of the engine, without fuel and oil, is 260 lb. and the gas consumption at the normal output of 60 hp. is given as 0.68 pt. per hp-hr. The corresponding figure for the consumption of lubricating oil is 0.02 pt. per hp-hr.

The Morehouse Light Plane Engine. By Harold E. Morehouse. Published in *Aviation*, June 1, 1925, p. 602.

This engine, known as the Model M80, was designed and built to conform to the National Aeronautic Association contest requirements for light plane engines. The 80-cu. in. engine is a two-cylinder opposed four-cycle air-cooled type having a bore of 3.75 in. and a stroke of 3.62 in. The compression-ratio is 5 to 1. The engine is rated at 28 hp. and a normal speed of 2500 r.p.m. The weight of the complete engine, dry, is 85 lb. Power and fuel-consumption curves obtained from calibration tests at McCook Field are given, and the various structural features are described in detail.

(*Concluded on p.* 32)

A "Surefooted" Car

MUD . . . . water . . . . ruts . . . . treacherous going! At times and places like this you appreciate the *"surefootedness"* that distinguishes the car equipped with the Ross Cam and Lever Steering Gear . . . . the stability, control and response that are always yours. Emergencies like this merely emphasize what Ross gives *all the time.*

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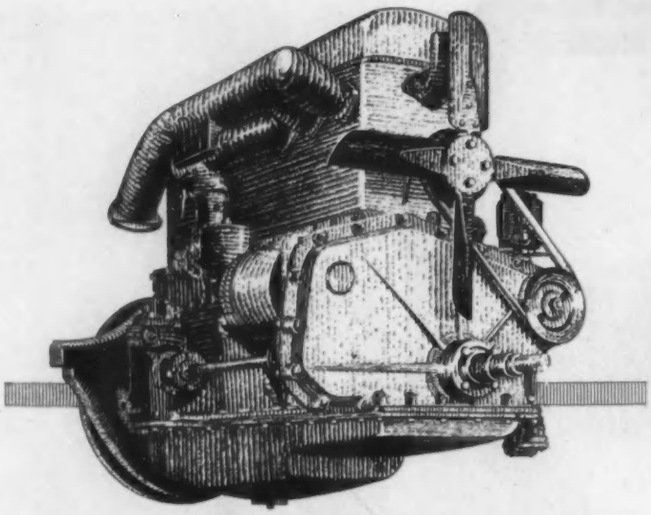

The Motor That Fights Waste

You men who follow keenly the costs of motor transportation know how often profit or loss lies in *that last mile-per-gallon.*

The builders of Wisconsin motors realize that *an extra mile or two per gallon* often spells operating profit instead of loss. Particularly when dealing with heavy-duty bus or truck motors, an account of the large quantities of fuel and oil used.

These highly developed motors are designed to deliver that extra mileage — consistently — over all other types of engines.

At the convenience of interested executives, Wisconsin will demonstrate these facts conclusively.

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Wisconsin "Z," 6-cylinder, 4½" x 5"; peak horsepower, 105 at 2000 R.P.M.
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Wisconsin "S-U," 4-cylinder, 4" x 5"; peak horsepower, 50 at 2000 R.P.M.

NOTES AND REVIEWS

Concluded

The Construction of Roads and Pavements. By Thomas Radford Agg. Published by McGraw-Hill Book Co., Inc., New York City. 519 pp.; 109 illustrations.

In this book the author, who is professor of highway engineering at the Iowa State College, has for his primary aim expounding the fundamentals of highway construction. Twelve different types of road are dealt with in detail in as many chapters. Such practical details as the exact material to be used for any particular road construction, the method of mixing it and even the tools used in handling it are discussed. Then general principles governing the surveying and planning of all kinds of road, the problems involved in draining and maintaining them and the testing of road materials also contribute to the treatment of fundamentals in the book. At the end of almost every chapter, the experience of some State is cited to point the lesson taught.

In addition to this fundamental discussion, the broader surrounding problems of highways and their use are taken up. A particularly interesting chapter deals with the economic principles involved in providing highway transportation at the minimum cost to both operators of vehicles and state highway departments. The value of a road is stated as its annual cost per unit of traffic. Methods of arriving at values for these factors are developed. Much attention is also given to the relation between the type of road and such vehicle costs as fuel, oil and tire consumption. The various conditions that should determine the choice of a road construction are enumerated, and their importance gaged.

Psychology in Business Relations. By A. J. Snow. Published by A. W. Shaw Co., Chicago. 562 pp.; 44 illustrations.

In this book the author, who is a member of the faculty of Northwestern University and director of psychological research, Yellow Cab Co., tells of the part played in business by one of the most influential elements involved, the human equation. Particularly interesting is the section dealing with the use of psychology in employment. The wide range of differences in human beings is brought out, and the necessity of knowing how to rate their qualities and characteristics is emphasized. As methods of evaluation, phrenology and physiognomy have certain definite fallacies, which are stated. The first step in finding the right man to fit the job, the author continues, is to define exactly what the job is. This is called occupational description or job analysis. The second step is to describe what qualities are needed to fill the job, or job specification. Finally, the individual must be tested to discover to what extent he has these qualities.

Methods by which the individual is tested fall into three classes, intelligence tests, special ability tests, and finally, trade tests. Much very practical information is given concerning special ability tests devised by the author. A study of the records of 6000 drivers of the Yellow Cab Co., covering a period of 1 year, showed that 46 per cent of the accidents had been caused by 18 per cent of the drivers. The problem was to develop tests that would indicate what men would fall into the 18 per cent class and weed out the unsafe drivers before employment. A careful study led to the conclusion that the accidents were due to three causes, bad judgment, emotional instability and carelessness or recklessness. A specially devised intelligence test was found to be practical in measuring judgment. To determine emotional instability, a test was developed in which the applicant acted as instructed under emotional disturbance, and the length of time required for a reaction was used as a criterion. To detect the third characteristic, a test was arranged that indicated general habits of neglect of safety in individuals. A table is given showing a decided agreement between the findings of the tests and the findings of experience.

Other information that will prove helpful to the man who must judge employes is given. Psychology in advertising and in selling are also dealt with extensively.

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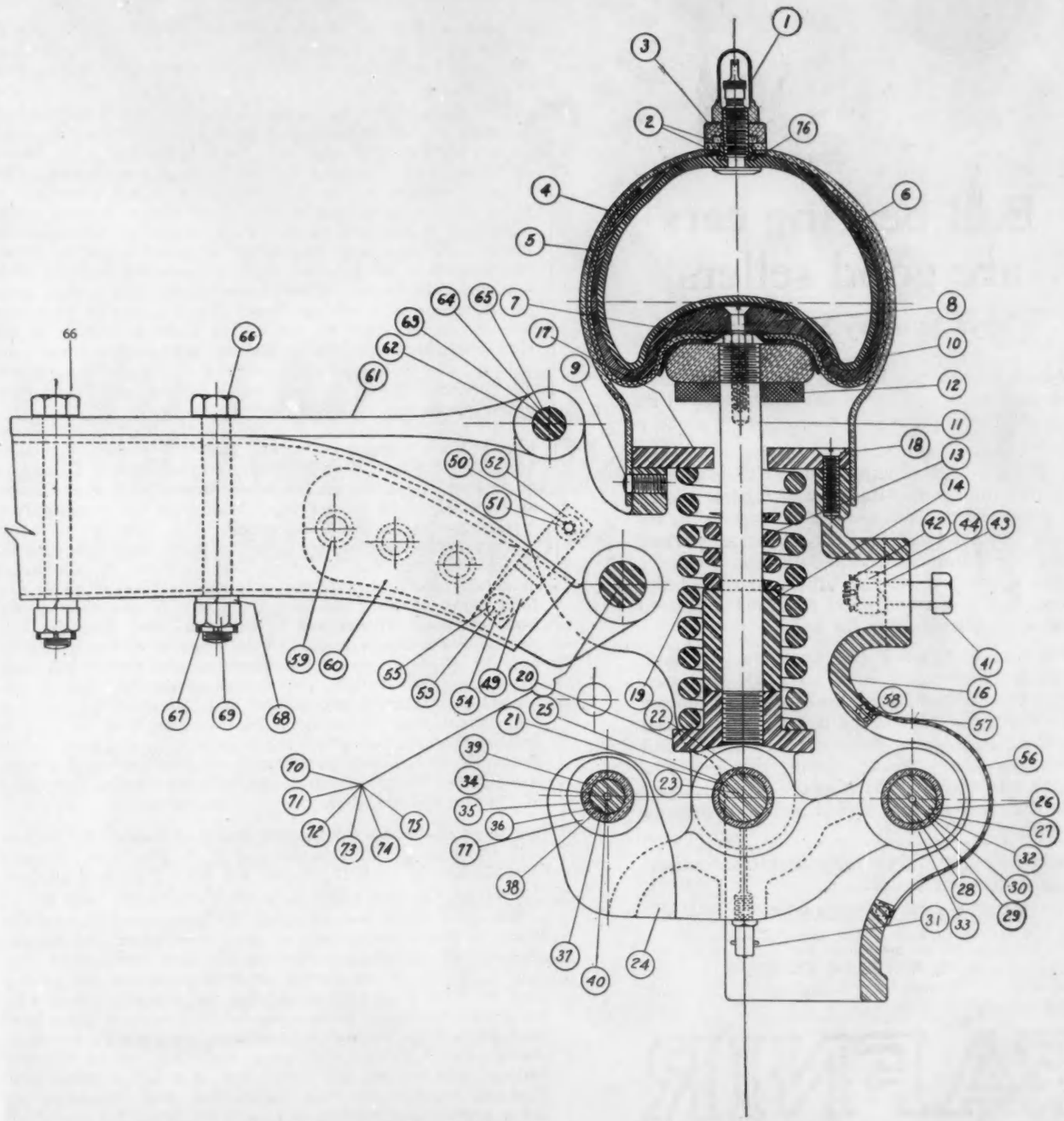
for all Pleasure Cars



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Ball bearing cars are good sellers

*Says Sammy Salesman**

When a fellow is selling a high grade ball bearing equipped car, a demonstration of its smooth running will almost always close a sale.

Only the other Sunday one of my customers met me at the garage where I keep the demonstration car. My car was in its usual place,—but another car was parked right in front of it, blocking the road. I tried alone to push the other car out of the way, but it was so hard to move I had to call on my customer for help.

The incident gave me an idea. I said, "Notice how hard it is to push this car. It takes two of us to do it. All a matter of bearings. Now take my car,—it is ball bearing equipped. Almost twice as big and twice as heavy as this other car, yet you alone can move it with ease. Try it."
He did, and my car rolled out as pretty as anything.

After that, it didn't take much salesmanship to get the order.

THE FAFNIR BEARING CO.

Makers of high grade ball bearings—the most complete line of types and sizes in America.

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BALL BEARINGS

THE MOST COMPLETE LINE OF TYPES AND SIZES IN AMERICA

NOTES AND REVIEWS

Continued

Manufacturers and Traders, Ltd., as to the causes of flats in solid tires. These troubles are due, according to the findings of the Committee, not to the tires, but to some defect in the vehicle. A number of probable sources of the damage are pointed out and analyzed.

Flow and Rupture of Metals During Cutting. By Walter Rosenhain and A. C. Sturney. Published in *Proceedings of the Institution of Mechanical Engineers*, No. 2, 1925, p. 141.

The main object of the investigation here reported was to study the deformation and flow of metal under the action of a simple cutting tool, and, more particularly, to observe the manner of separation by which the chip is formed. This object was pursued by studying the internal structure of chips in process of formation under different cutting conditions and in different stages of development. To make the observation as simple and direct as possible and to reduce the number of independent variables entering into the problem, the cuts studied in the present investigation were made on the edges of revolving discs. The cut was in each case stopped as suddenly as possible to leave a portion of the chip adhering to the stock. Subsequently sections were cut, polished and etched through both the chip and the surrounding metal to reveal the internal structure and the flow or deformation that it had undergone.

The material operated upon was in the form of cylindrical bars initially 3 in. in diameter. Ordinary carbon-steel parting tools were used in performing all operations. The speed of rotation of the bar was kept constant so as to give a linear speed of about 50 in. per min. throughout the investigation. No lubricant was used.

Among the observations reported as a result of the investigation was the fact that according to the conditions of cutting the separated metal takes the form of three distinct types of chip, the tear, the flow and the shear types. The investigation also led to the conclusion that the best results in cutting in regard to the removal of the maximum amount of metal per unit distance of tool travel, the least irregularity of surface, the closest agreement between intended and actual depth of cut and the minimum wear of tool is obtained by using a top-rake angle a very little smaller than that at which the heavily deformed zone before the nose of the tool just disappears, in conjunction with the greatest depth of cut which still allows the formation of the "flow" type of chip.

A Flow Calorimeter for Specific Heats of Gases. By Nathan S. Osborne, H. F. Stimson and T. S. Sligh, Jr. Bureau of Standards Scientific Paper No. 503. Published by Government Printing Office, City of Washington. 151 pp.

The calorimeter was designed for measuring the specific heats of gases accurately at pressures below 100 atmospheres and temperatures below 150 deg. cent. (302 deg. fahr.). It is of the flow type with provision for adding heat electrically and for measuring the temperature rise by platinum resistance thermometers. Refinements have been adopted to keep the size within limits appropriate for moderately small samples of pure materials, avoid thermal leakage and control the conditions that affect steadiness. Thermal leakage by solid conduction was minimized by using appropriate lengths, sizes and materials for all tubing and supports; leakage by gaseous conduction and convection was avoided by evacuating the space surrounding the calorimeter system; and leakage by radiation was opposed by exposing the calorimeter system only to surfaces maintained at the respective temperatures of the system within.

The calorimeter was made responsive by avoiding large or detached heat capacities, but, in addition, means were provided for keeping both power input and flow constant. Constancy of flow was accomplished through the automatic

(*Continued on p. 20*)

The Stewart-Warner Valve installed on the exhaust pipe. Heavy asbestos gaskets make this installation absolutely leak-proof. The one valve fits practically all makes of cars.

All The Heat -and Dash Controlled to Any Degree -

QUICK HEAT—but—controlled, so that the occupants of the car may have any degree that is comfortable.

It meets both summer and winter requirements perfectly.

No need to drive several miles before the car is flooded with heat. It comes QUICKLY to a cosy temperature.

The drawn steel element, which is used instead of a cast iron one, facilitates heat radiation.

There is a Stewart-Warner Heater installation for every make of car.

Now is the time for manufacturers to get our quotations. Dealers are urged to anticipate a busy season approaching on heaters.

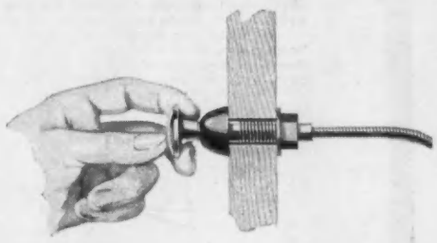
STEWART-WARNER SPEEDOMETER COR'N
CHICAGO - ILL.

List Prices

Small Model—
$18

Large Model—
$22

(West of 100° Meridian $19.50 and $23.50)



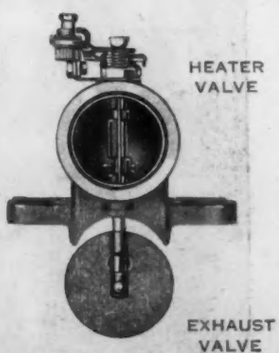
The Stewart-Warner Heater is easily operated by a convenient dash control, making it possible to regulate the temperature of the car interior to a fine degree. With a Stewart-Warner, the car owner and his guests ride in perfect comfort.

Stewart-Warner Car Heaters

ONE OF THE STEWART-WARNER ACCESSORY FAMILY

The Stewart-Warner Exhaust Valve is, in reality, two valves. It has two dampers that work at right angles to each other—one closing the exhaust pipe, while the other opens the car heater intake, and vice versa.

This feature of the Stewart-Warner Double Exhaust Valve conserves the heat without any loss and provides a supply to meet any requirement.



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In answer to your inquiry with reference to the service and satisfaction that has been rendered by Shafer Roller Bearings as used on the Maxwell cars, we are pleased to inform you that to date we have received results that to the writer's estimation, have been second to none.
As you know, these bearings have been a standard equipment on the Maxwell for over two years and it is from this fair test that we base our hearty recommendation.
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NOTES AND REVIEWS

Continued

control of the pressure in the calorimeter supply line and protection of the discharge line from the effect of fluctuations in condenser pressure. Provision was made for evaluating the small corrections for residual thermal leakage and for the effect of pressure drop through the calorimeter. Special accessory apparatus was provided for the control and measurement of temperatures and pressures.

The instrument has been tested in an extensive series of measurements of the specific heat of ammonia, the results of which are published separately, at pressures between 0.5 and 20.0 atmospheres and temperatures between —15 and 150 deg. cent. (5 and 302 deg. fahr.).

Announces Process to Make Anti-Knock Gasoline Direct from Crude. By Paul Truesdell. Published in *National Petroleum News*, July 15, 1925, p. 25.

According to this account, this new fuel is manufactured directly from the crude petroleum and contains no chemicals except those present in the oil itself. In its production a large proportion of the paraffin members of the hydrocarbon family is converted into naphthene members by a catalytic cracking process. The catalyzer, the name of which is kept a secret, is said to be common and inexpensive. The characteristics of the fuel are given as: naphthenes, about 2/3; olefines, about 1/3; aromatics and paraffins, just a trace; color, from No. 10 to water white, as desired; and distillation range, as desired. Its anti-knock value is said to be about one-half that of benzol.

The fuel can be made from all crudes, and production will amount to about 30 per cent of the crude. Concerning the cost, the claim is made that four cracking units sufficient to produce 250 bbl. a day could be installed at an expense of $200,000. The operating charge is figured at 49 cents per 100 gal. of charge, or about 25 cents a bbl.

Alcohol Motor-Fuel from Molasses. By E. C. Freeland and W. G. Harry. Published in *Industrial and Engineering Chemistry*, July, 1925, p. 717.

Few internal-combustion engines designed especially for the use of alcohol as fuel have been put on the market. To test the use of alcohol as motive power, the authors have had to substitute it in engines originally intended for gasoline. The paper presents the results of these experiments, which have been carried out with automobiles, tractors and stationary engines, used under ordinary operating conditions. Alcohol and alcohol-ether motor-fuels have been used in the tests. While no radical changes had to be made in the engines, a few adjustments were necessary. These are described, as well as the methods of securing the best results.

Some of the advantages of alcohol over gasoline as a fuel in an internal-combustion engine are said to be that with it less heat is generated, cylinder temperatures are lower, the rate of flame propagation is less and the pressure more nearly uniform, greater power is developed, little or no carbon is deposited and higher compressions are possible. The disadvantages enumerated are three: low volatility of the air and alcohol vapor, leading to difficulty in cold starting; the difference in the ratio according to which the explosive mixture of air and alcohol is formed, as compared with the gasoline-air mixture; and the fact that an explosive mixture of air and alcohol vapor is formed within narrower limits than the mixture of air and gasoline, and consequently the engine has a much lower speed flexibility.

Lubricating Greases, Their Composition, Properties and Application. By J. E. Babb. Published in *National Petroleum News*, July 15, 1925, p. 82.

Lubricating greases are classified as the fatty acid soaps of the elements calcium and sodium. In the order of their

(*Continued on p. 22*)

Better finish at lower cost!

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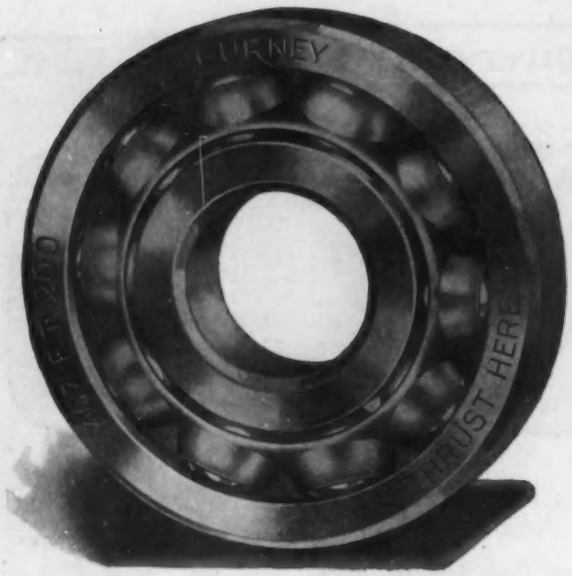

One Bearing for Two Loads

The Gurney Radio-Thrust bearing will take both radial and thrust load. It occupies less space than two separate bearings (one for the radial load and one for the thrust load)—has longer life and renders dependable service. Why use two bearings where one will answer the purpose? Simplify design—reduce costs.

Gurney Engineers, with many years experience, are at your disposal on bearing questions.

Marlin-Rockwell Corporation

Jamestown, N. Y.

18322

GURNEY BALL BEARINGS

NOTES AND REVIEWS

Continued

importance, the fatty materials that enter into the composition of the soaps are tallow, hog fat, lard oil, horse oil, cotton seed oil, cocoanut oil, rosin and rosin oil. Soap is valued according to the titre or melting point of the fatty acids, which varies from 32 to 42 deg. cent. (89 to 107 deg. fahr.), as the higher the melting point, the more mineral oil may be incorporated in the grease. The general names of cup, fibre or sponge grease cover all varieties.

A description is given of the process of making grease, and then the author turns to a consideration of its uses in lubrication. He makes the prophecy that with the decrease in our petroleum supply, the use of oil as a lubricant will be discontinued to a considerable extent, and grease be substituted.

An enumeration is made of some types of machinery where grease is now used as a lubricant, and the hardness test for showing the suitability of any particular grease for a certain purpose is described.

Plan Worked Out for Standardization of Oil Viscosity Tests. Published in *Automotive Industries*, July 23, 1925, p. 136.

The Committee on Viscosity Standards of the American Petroleum Institute recently issued recommendations for eliminating discrepancies in the viscosity results obtained by different observers with the same oil and same type viscosimeter. An account is given of the research on which the recommendations are based, in the course of which both the Saybolt and Furol instruments were investigated. The recommendations for the standardization of each, with correction tables, are quoted.

Street Traffic Control. By Miller McClintock. Published by McGraw-Hill Book Co., Inc., New York City. 233 pp.; 25 illustrations.

Traffic control is a problem, the complexity and interest of which increases steadily with the increase in the number of automotive vehicles using our streets and highways. The author of this latest effort to reach a solution is assistant professor of municipal government at the University of California and consultant to the Los Angeles Traffic Commission. In preparation for the writing of this book, he made a study of the traffic situation in the principal American cities. His presentation of the problem as it confronts municipalities today is vivid, and his suggestions for its amelioration practical.

After tracing the origin and growth of street traffic-congestion, the author tells how, by a traffic survey, an accurate understanding of the magnitude and nature of the problem can be obtained. The causes of congestion are said to fall into two chief divisions, the street plan and the character and regulation of traffic. City streets, he says, should be graduated in width according to the demands to be made upon them, and in measuring this demand consideration should be given to the fact that the greater the speeds permitted, the greater is the clearance to be allowed for between vehicles. Traffic moving at 15 m.p.h. is said to require the minimum leeway of 3 ft. How more traffic space may be provided is next taken up. Some expedients mentioned are cutting through additional streets, setting back building lines, building arcaded sidewalks, double-level streets or vehicular tunnels.

Among the most recent refinements in traffic regulation is the attempt to keep traffic in constant motion. This plan, characterized as the most promising yet devised, is put into operation through the signaling system. When this method of regulation is in force, the lights on a thoroughfare flash, not all at one time, but in succession. Cross traffic moves between the waves of traffic on through streets, and by alternating the waves on parallel through streets the constant flow may be maintained on all thoroughfares. A sys-

(*Continued on p. 24*)

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Relleum Brass Forgings are adaptable to every line of manufacture where brass parts are used.

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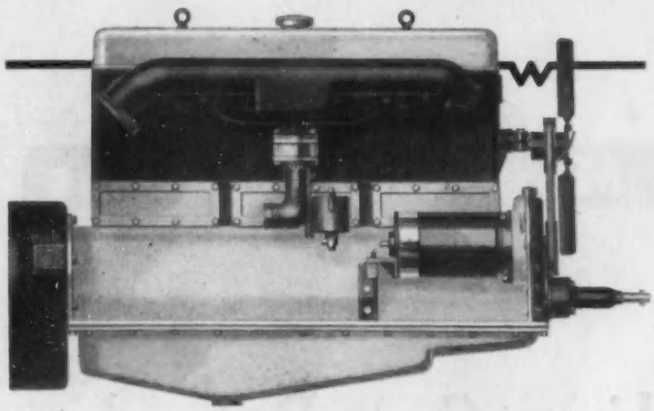


"12 to 13 M.P.G. for 50,000 Miles!"

Five Menominee Busses (Wisconsin-powered) have averaged from 12 to 13 miles per gallon for 50,000 miles.

These busses, seating 19 persons, operate between Huntington and Charleston, West Virginia. They weigh 9,000 pounds, loaded.

The route has one ten per cent grade.

Two of the busses at 50,000 miles had never had the valves ground. They are powered with the Wisconsin "Y" motor, brief specifications of which appear here. Its companion motors can be depended on for similar performance - economy.

Write for the facts of Wisconsin's triple saving—reaching builder, seller and buyer.

Specifications:

Model Y: Six cylinders; Bore 3⅜"; Stroke 5"; Brake Horsepower 30 at 1000, 40 at 1400, 50 at 1700, 75 at 3000 R.P.M. Piston displacement 268.3 cubic inches.

Model Z: Six cylinders; Bore 4½"; Stroke 5"; Brake Horsepower 53 at 1000, 77 at 1500, 95 at 2000, 105 at 2400 R.P.M. Piston displacement 477 cubic inches.

Model S-U: Four cylinders; Bore 4"; Stroke 5"; Brake Horsepower 30 at 1000, 43 at 1500, 50 at 2000 R.P.M. Piston displacement 251 cubic inches.

MORE POWER per CUBIC INCH

Wisconsin Motor Mfg. Co.

Milwaukee, Wis.

Wisconsin CONSISTENT

NOTES AND REVIEWS

Continued

tem of this type calls for a careful study to determine the time to be allowed between the flashing on of the consecutive lights.

The conditions under which parking should be prohibited are outlined, and the author then gives an interesting discussion of a phase of the traffic problem sometimes neglected, the regulation of the pedestrian. He points out that, in general, the law has protected the pedestrian, even when he does not act with good judgment in crossing traffic streams. He predicts that this sentiment will change to some extent and that obstructions will be erected to keep the pedestrian off the street between intersections in the same way that the curb keeps vehicles off the sidewalk. A group of regulations for pedestrians which forms a part of the New Orleans Traffic Ordinance is quoted as one of the best systems of its kind.

Chapters on the municipal traffic code, the traffic bureau, police equipment and auxiliary devices for traffic regulation and the treatment of offenders conclude the book.

Generating Units of United States Helium Gas Power Plant. By Z. W. Wicks. Published in *Power*, July 7, 1925, p. 8.

A description is given of the operation of the helium production plant constructed by the Government at Fort Worth, Tex., in 1920 and 1921. This was built after the discovery that the non-explosive gas so essential to heavier-than-air flying was present in the natural gas from the Petrolia, Tex., fields.

In the process of manufacture, the natural gas is taken from the lines leading to Fort Worth, the helium is removed and the gas is recompressed and returned to the pipe lines. At first the compressors of 42,000-cu. ft. per hr. capacity needed for the extraction processes were motor driven and electrical energy purchased from the local public utility. This proved to be too expensive, therefore twin 500-hp. gas engines were installed to supply the power for the motor-driven compressors. Various economizers used in connection with the gas engines have greatly cheapened the helium production process. The estimate is made that the saving over the cost of purchased energy will pay for the engines in 4 years.

The Nobile Mechanical Landing System. By Lieut-Col. Umberto Nobile. Published in *Aviation*, July 20, 1925, p. 63.

In this system a special automatic anchor is attached to the free end of the landing cable. A windlass is provided, to which the other end of the cable is fastened. On the ground are three braking ropes converging to one point at an angle of 120 deg. to each other. Sandbags, resting on supports, are fastened at intervals along the ropes, while a group of weights at the free end of each acts as a counterweight and imparts the desired tension to the ropes.

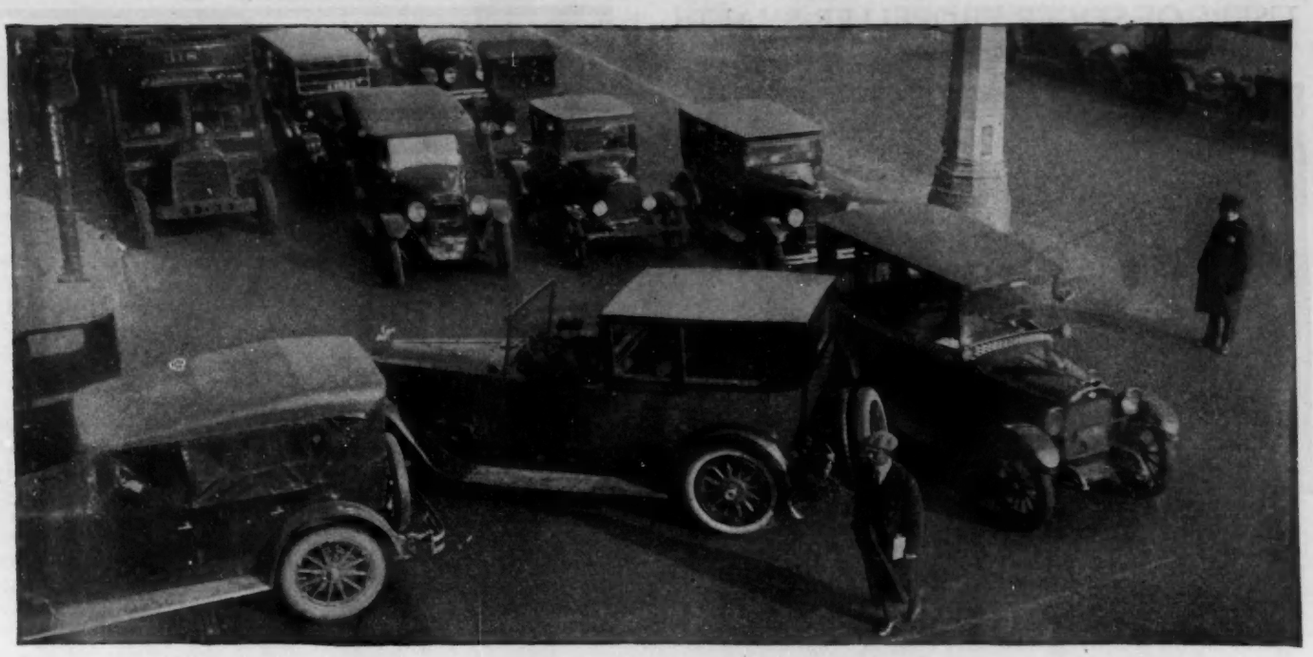
In effecting a landing the anchor is lowered until it touches the ground. The airship is permitted to advance slowly until the landing cable comes in contact with one of the three braking ropes. The result of further drifting is to permit the anchor to grip the braking rope.

The article describes two forms of automatic anchors that might be used, the windlass and the steps that must be taken to adapt the system for landing on the water.

Inertia Factors of Ellipsoids for Use in Airship Design. By L. B. Tuckerman. National Advisory Committee for Aeronautics Report No. 210. Published by National Advisory Committee for Aeronautics, City of Washington, 7 pp.

This report is based on a study made by the author as a member of the Special Committee on Design of Army Semi-Rigid Airship RS-1, appointed by the National Advisory Committee for Aeronautics. The increasing interest in airships

(*Continued on p.* 26)



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Strom Ball Bearings

Single-acting thrust bearing, flat seats (grooved races) 1100-F Series

Double-acting thrust bearing, flat seats (grooved races) 2100-F Series

Single-acting, self-aligning thrust bearing, leveling washer, 1100-U Series

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THE qualities sought in the highest class of motor cars are dependability, smooth power, quick responsiveness, luxury of appointments and easy riding.

One of the finest cars made has Strom Ball Bearings in 42 locations, necessitating 29 different types and sizes.

Strom Ball Bearings are specified by discriminating automotive engineers because they have proved their right to recognition. They are made of special ball bearing steel, hardened throughout to insure uniform density, elasticity and durability. They are produced by skilled workmen and the most modern machinery. At every step in their manufacture they are subjected to scrupulously careful inspection, resulting in uniformity and accuracy.

They are made in a wide range of types and sizes, all standardized and interchangeable with other standard makes.

Write to us for catalog, price list and other literature. Our engineers are at your service.

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Super-Strom deep groove, radial bearing

Double-row, deep-groove, radial bearing, bronze retainer

Angular contact bearing, combination radial and thrust

Adapter type bearing, with sleeve

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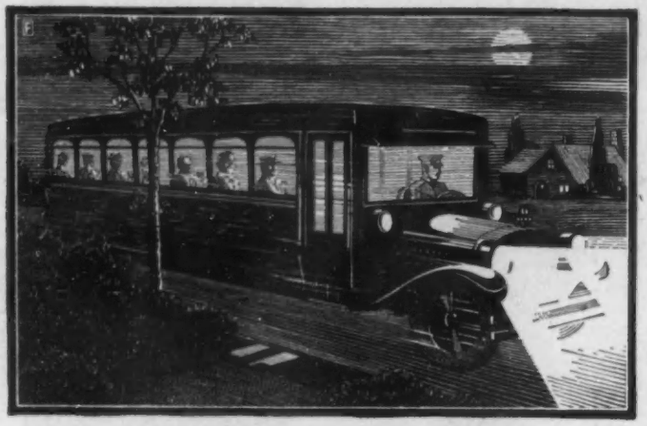

Adopted by leaders in the bus field

EVER since Spicer universal joints propelled the horseless carriages of 1904 vintage, these units have been used on a majority of the carefully built passenger cars and trucks.

Prestige alone, however, would not have influenced the most progressive bus designers in the country to adopt Spicer Propeller Shafts, for bus problems are different. Their own tests proved that the Spicer serves longest at least cost, running along silently and faithfully month after month with no more attention than regular lubrication.

This is why Spicer Universals are used on

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In addition to these manufacturers, there are large operators who equip every bus in their fleets with Spicer Propeller Shafts, because their operating records testify that Spicer maintenance costs are lowest.

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NOTES AND REVIEWS

Continued

has made the problem of the potential flow of a fluid about an ellipsoid of considerable practical importance. In 1833 George Green, in discussing the effect of the surrounding medium upon the period of a pendulum, derived three elliptic integrals, in the terms of which practically all the characteristics of this type of motion can be expressed. The theory of this type of motion is given by Horace Lamb in his Hydrodynamics, and in applications to the theory of airships by many other writers. Tables of inertia coefficients derived from these integrals are available for the most important special cases.

These tables are adequate for most purposes, but occasionally knowledge of the values of these integrals in other cases where tabulated values are not available is desirable. For these reasons a collection of formulas was assembled with which the values can be computed directly from standard tables of elliptic integrals, circular and hyperbolic functions and logarithms without the need of intermediate transformations. Some of the formulas for special cases, notably the elliptic cylinder, prolate and oblate spheroids and others, have been published before, but the general forms and some special cases have not been found in previous publications.

Some Aspects of the Comparison of Model and Full-Scale Tests. By D. W. Taylor. Published in the *Journal of the Royal Aeronautical Society*, July, 1925, p. 300.

In his analysis of the value of model tests, the author follows the methods developed by Dr. Buckingham in this country. He does not enter upon a discussion of the general formula regarding model-test interpretation but considers only the case of objects in motion in a fluid medium.

His first step is to enumerate the quantities that affect the performance of the model and the full-scale airplane. They are: resistance of the object, its speed, its size, the density of the fluid, the viscosity of the fluid, the compressibility and the acceleration of gravity. In addition certain ratios are used to express physical facts that are independent of size. These quantities are analyzed, and their relation to each other explained. Formulas are then developed by which model findings are translated into predictions of full-scale performance.

Among the examples of model tests analyzed are those dealing with airfoils, with aircraft propellers and with the combined action of the propeller and its airplane. The illustrations include three diagrams showing lift and drag characteristics of airfoils in the variable-density wind-tunnel, one showing ideal and one actual propeller efficiency in the air, experiments made with a group of propeller models varying systematically, and a number showing results with both model and full-scale tests.

The Reduction of Airplane Flight-Test Data to Standard Atmosphere Conditions. By Walter S. Diehl and E. P. Lesley. National Advisory Committee for Aeronautics Report No. 216. Published by National Advisory Committee for Aeronautics, City of Washington. 18 pp.

If airplane flight-tests are to serve a useful purpose, the observed performance must be easily reduced to standard conditions. To provide practical methods by which this reduction can be made with the minimum of labor is the object of this paper.

The first part gives a very simple approximate method of reducing performance in climb and is particularly adapted to work not requiring extreme accuracy. The method is based on the assumption that under any normal conditions of pressure and temperature, the instantaneous climb has the same value that it would have at the same density in standard atmosphere. In the second part a more elaborate and more accurate method applicable to general flight-test reduction is outlined. The third part gives the conventional

(*Concluded on p.* 28)

40 MILLION HAYES WHEELS IN 17 YEARS

Is *your* car Hayes-wheel equipped?

The fact that car owners look for the attached lug on the rim, the name Hayes on the lug, whether on wood, wire or disc wheels that they may have the comfortable feeling of knowing that the maker of their car has given them the last word in wheel and rim equipment, means something to car engineers.

They no longer need dread a flat tire, for the time required to change Hayes rims is reduced to a minimum. No loose lugs to fumble for in the dirt, and adjust.

The lugs are attached to Hayes rims and are always in position. They are through with squeaky rims.

Hayes rims are locked in position, cannot slip and cannot run out of true. Every lug acts as a driver. These features lessen tire wear and eliminate stripped valve stems.

Hayes wheels are the result of seventeen years' experience in manufacture. In this period forty million Hayes wheels have been put in service on cars of all classes from America's lowest to highest priced.

Car owners not now enjoying the advantages of Hayes Wheels and rims should specify this equipment on their next car.

HAYES WHEEL COMPANY, *Manufacturers*. Jackson, Michigan

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The MAKING OF MALLEABLE

A New Book by

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THE making of malleable is treated in a simple and concise manner in this brochure—recently off the press. Certain exclusive features are referred to; but in the main, its object is to indicate the broad field of malleable, and to eliminate the highly technical data that confuses rather than enlightens the layman. We will be glad to send it upon request. If more convenient, use the coupon for this purpose.

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NOTES AND REVIEWS

Concluded

method of calibrating air-speed indicators and reducing the indicated speeds to true air-speeds. An appendix gives working tables and charts for the standard atmosphere.

Report of Torsional Test of Curtiss NBS-4 Fuselage. By Edgar R. Weaver. Air Service Information Circular No. 513. Published by the Chief of Air Service, City of Washington. 4 pp.

The object of this test was to determine the torsional deflection of the NBS-4 fuselage before and after rebuilding. Loads were imposed on the fuselage structure, and the resulting torsional deflection was measured. The following changes were then made in the construction. The streamline diagonal wires were replaced with heavier round wires on all four sides of the fuselage. The transverse diagonal wires ahead of the bomb compartment were replaced with round rods, but to the rear of the bomb compartment the original streamline transverse wires were used.

From the measurements obtained the conclusion is drawn that through these changes the torsional deflection was reduced 50 per cent at the point of greatest angular torsional deflection.

Torsional Test of Martin-Bomber NBS-1. By Edgar R. Weaver. Air Service Information Circular No. 515. Published by Chief of Air Service, City of Washington. 1 p.

The object of this test was to determine the torsional deflection of the Martin bomber fuselage. This was the third airplane to be so tested, and the following figures are given to show the comparative results:

Airplane	Maximum Angle of Twist under Worst Condition, Deg.-Min.
NBS-3 G. Elias bomber	0 54
NBS-4 Curtiss	1 22
NBS-1 Martin	1 47

The Static Proof Test of the Aileron, Stabilizer and Elevator of the Cox-Heinkel Observation Airplane P-377. By Edgar R. Weaver. Air Service Information Circular No. 514. Published by Chief of Air Service, City of Washington. 2 pp.

The horizontal tail surfaces and ailerons of the Cox-Heinkel airplane were static tested to determine whether they were up to the strength requirements and safe for flight. According to the results given the horizontal control surfaces and the control mechanism supported the required proof load and functioned properly during the test. The elevator, stabilizer, aileron and their controls were found to be safe for flight.

The Douglas Transport. Published in *Aviation*, June 1, 1925, p. 606.

The latest production of the Douglas Co. is the Army Transport C1. This airplane is designed to carry six passengers and two pilots but can be adapted to carry such loads as a Liberty engine. The design is said to follow conventional lines. This airplane was produced in response to a request for bids issued by the Air Service.

Some of the characteristics are: wing span, 60 ft.; overall length, 36 ft.; overall height, 14 ft.; wing area, 800 sq. ft. and total dead load, 3900 lb.

Cox-Klemin Mail Plane. Published in *Aero Digest*, June, 1925, p. 315.

The Cox-Klemin Night Hawk was designed especially for night mail service. Particular attention has been given to visibility, stability and controllability. Its high speed is 130 m.p.h.; landing speed, 45 m.p.h.; rate of climb, 1000 ft. per min. and absolute ceiling, 20,000 ft.